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The Surgical Treatment of Pectus Excavatum Utilizing an Adhesive Hemicast

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The purpose of this paper is to summarize the findings and results of surgical therapy for pectus excavatum performed on 96 cases over a seven year period. We believe we have developed a technical method for correcting this deformity that is eminently satisfactory and almost foolproof, both physiologically and cosmetically, even in severe deformities. A modification of this method has been used in the treatment of approximately 50 cases of stove-in chest injuries. It has proved to have distinct advantages over other methods of traction and counter traction, particularly in relief of pain, early mobilization of the patient, and ease of tracheo-bronchial toilet.

Pectus excavatum is a congenital deformity, with insidiously progressive physiologic, orthopedic and psychologic manifestations. It is not uncommon, and a definite number of cases are severely incapacitated by it. In this deformity, the body of the sternum is displaced backwards to form a concavity which may reach to the vertebral bodies. The lower costal cartilages on either side angulate on the antero-posterior plane towards the xiphoid, which is the apex of the funnel. The deformity may be symmetrical or asymmetrical and is commonly noted soon after birth. The decrease in antero-posterior diameter of the thorax impedes elevation of the ribs and prevents satisfactory clearing of the tracheo-bronchial tree, causing greatly increased susceptibility to respiratory infections, particularly in early life. The effect on the cardiovascular system is to reduce cardiac filling with a decreased minute volume. This is probably accentuated by torsion or angulation of the great vessels from displacement of the heart, usually to the left. In the extreme instances there is compression and rotation of the displaced heart between the narrowed walls of the distorted hemithorax. The dyspnea is attributed usually to decreased cardiac function rather than to compression of the lung and may be considered due to the mechanical factors analagous to constrictive pericarditis. The whole chest is flattened and the abdomen is often protuberant in contrast. There is an upper thoracic kyphosis, with neck and shoulders pulled forward, and a flattening of the lower thoracic spine. Asymmetrical deformities may produce a severe degree of scoliosis of the thoracic vertebrae with a marked lateral protusion of the anterior chest wall.

In 1596, Barrhinus described this lesion accurately and stated that the pull of the diaphragm was the causative factor. Most present writers on the subject agree that the diaphragm is the active productive force. (Brown[1] 1939; Ravitch[13] 1949; Brodkin[2] 1953; Lester[11] 1954; Hausmann[7] 1955; Chin[4] 1957). Other writers, particularly Sweet,[15] and Koop[9] believe that in many of these deformities, skeletal overgrowth may be the factor. Welch[17] points out that there appears to be no abnormality at the costochrondal junctions and longitudinal sections through this zone, after decalcification, show no gross microscopic alterations.

Brodkin[2] felt that the muscular component of the diaphragm derived from the septum transversum was deficient in muscle fibres, and because of this weakness, it was pulled in by the more powerful surrounding muscle, and thus had no option but to descend with the central tendon, dragging the lower sternum with it. Chin[5] has probably produced the most confirmatory evidence in support of Brodkin's theory, by taking muscle biopsies from the anterior portion of the diaphragm in cases of pectus excavatum and in controls. He found that in cases of funnel chest, the anterior portion of the diaphragm was deficient in muscle and had a great deal of fibrous tissue mingling with islets of muscle. In the controls, there was well-developed normal muscle tissue. He also pointed out that bilateral paralysis of the phrenic nerves by local anesthesia caused a cessation of the deformity in any stage of respiration.

There seems little doubt about a congenital element in this problem. It is always present at birth in these individuals who remain in the progressive or worsening group. A familial tendency has been demonstrated by Lester and Sainsbury[12] who believe that the defect is usually recessive and that either funnel chest or pigeon breast may appear in the same family.

Indications for Operation

The prevention or correction of cardiorespiratory embarrassment should be considered a prime indication for the operative correction of a pectus excavatum. The physiologic disturbances due to displacement or compression of the heart are usually delayed to adolescence or later. A possible explanation of this factor is that as age advances, the mediastinum becomes more fixed and the heart is more directly compressed by the depressed sternum. Probably all patients who have any degree of depression of the sternum will develop some cardiac disability. This usually presents a dyspnea which may be of a distressing degree even on moderate exertion; precordial pain; palpitations; arrhythmias; syncope on moderate exertion. Exceptionally, these cases may present in frank heart failure. A slight systolic precordial murmur is often heard. Angiocardiographic studies may show dilatation of the right atrium and ventricle. Circulation time is often prolonged. Electrocardiographic tracings are often reported as abnormal, but there appears to be no type uniformly present or attributable to pectus excavatum. Cardiac catheterization may show, in severe cases, a markedly diminished cardiac output with an elevation of right auricular and ventricular pressures, particularly with exercise. It is in cases that exhibit moderate to severe cardiac disability that one obtains the most spectacular and gratifying results.

Many of these children with a pectus excavatum are under-developed. They give a history of more frequent respiratory infections than usual. Their dyspnea may not exclude them from games, but their exercise tolerance is definitely limited. These symptoms appear predominately in the younger age groups, although some respiratory symptoms are present in all ages. We have operated on three cases of pectus excavatum who had cerebral palsy. Following operative repair, the disappearance of their almost constant respiratory infections, with general improvement in their well being, was striking.

Respiratory studies on infants and the younger age group are not practicable. Brown[2] found that the estimation of maximum breathing capacity was the best single test of the status of respiratory physiology. This test will indicate the progression of the disease pre-operatively as well as the results of operation. Hansen[3] studied four cases aged 18 to 25 years pre- and postoperatively by bronchospirometry. All cases were considerably improved following surgery. Adequate and prolonged physiotherapy postoperatively will enhance the respiratory improvement greatly.

It would seem logical from the orthopedic point of view that any case of pectus excavatum that shows progression after infancy should be offered operative cure. Progression of the deformity probably bears a direct relationship to the degree of paradox. If the child begins to show evidence of sternal angulation, and fixity at rest, it is wrong to temporize. Surgery is recommended in order to minimize the operative procedure and also as a prophylaxis against permanent thoracic cage deformities. Asymmetrical lesions produce the most marked orthopedic deformities. There may be a moderate to severe thoracic scoliosis. The anterior chest wall protrusion on the side opposite the deformity may be related to overgrowth of ribs on that side. If the sternum angulates to the left to any degree, it is our experience that these cases have more cardiac embarrassment than do the central type.

One of the most striking postoperative improvements we have noted has been the psychologic change. This is often volunteered by the parents. The psychologic hazard is probably more severe than we realize. This is most noticeable in adolescent boys. We consider surgery for cosmetic reasons alone is indicated provided the deformity is severe enough, and one can offer a procedure involving minimal risk, slight morbidity and producing a satisfactory esthetic result.

Age of Election for Operation

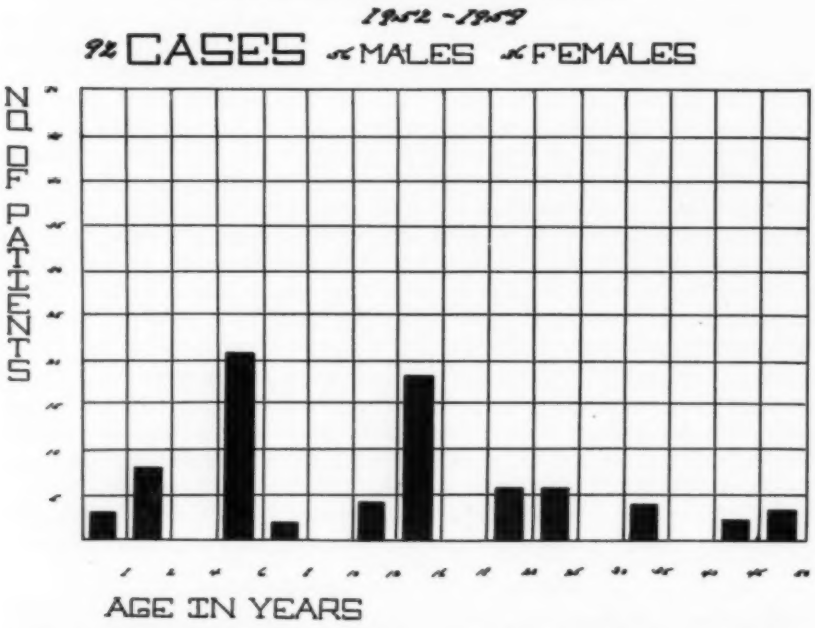
From our experience, we feel that if undesirable symptoms are present, there is no age from infancy to middle life when surgery is contraindicated.

With few exceptions, cases which are presented in the first year of life are observed at six monthly intervals and the progression of the deformity noted. If the child is symptomless and a cosmetic repair is contemplated, it is preferable to wait until the fourth or fifth year of life for treatment. However, earlier operation should be advised in cases showing progression of the deformity and the paradox, particularly if the child develops a bad posture, is underdeveloped and has more fre-

quent respiratory infections than usual. It is impossible from experience to foretell those cases which will develop serious physiologic imbalance and deformities and we feel that the majority will develop at least some degree of upset. This view is borne out by Bell's[4] questionnaire to a group of chest physicians who observed a large number of these cases. There was unanimity of opinion that any case presenting in childhood with a moderate to severe deformity should be operated on. The majority of observers were of the opinion that all cases in adult life suffer from some cardiac and pulmonary disability.

Pectus excavatum which produces cardiac or respiratory trouble in adolescence or early adult life presents no problem regarding the decision to do surgery. They all should be treated surgically. In cases with fairly severe orthopedic deformities, planned and energetic physiotherapy post-operatively will do much to relieve and compensate for the deformity. This is true even in the third and fourth decade.

TABLE 1—THE AGE GROUPS AT WHICH 92 OF THE REPORTED SERIES WERE PRESENTED FOR SURGERY



The above table illustrates the following facts: pectus excavatum can be a surgical emergency in the newborn, as two of this series required surgery shortly after birth, because of severe respiratory difficulties. The majority of cases probably should be operated upon, if they show progression of the defect, at approximately four years of age. A considerable proportion of cases present with disability in the early and late "teens" for surgery. Also in this group are cases that become acutely aware of their esthetic appearance and request improvement. This factor is more pronounced in the male sex. In the age group of 25 to 50 years there is

a certain number with deformity and disability who have not had the opportunity for surgery. This group, although much of the secondary orthopedic deformity only can be improved upon, should be offered surgery, with agreeable results to the patient and surgeon.

Operative Technique

The original and outstanding work of Brown[2] and later of Ravitch[14] and Lester[10] is the basis of all major thoracic reconstructions today. The operative techniques are based on the following principles: the mobilization of the sternum by adequately resecting the deformed cartilages and ribs if indicated, preserving the perichondrium and periosteum; stripping the posterior surface of the sternum from a diaphragmatic insertion; fixation of the sternum in an overcorrected position until stabilization takes place; a transverse cuneiform osteotomy at or near the sternomanubrial junction and the corrected position maintained by nonabsorbable sutures. The result of any operative procedure depends on doing the multitude of intricate details well. From our experience, we have drawn certain conclusions and introduced some modifications on the various steps of this procedure which we feel are essential to obtain a satisfactory result.

Although a transverse incision at the deepest point of the funnel gives the best approach to the sixth and seventh costal cartilages, we consider a longitudinal incision to give the ideal over-all exposure for a radical resection of the deformity. We found that as time progressed, our incision shortened, so that it extended from just below the third costal cartilage to approximately one or two finger breadths below the xiphoid, in the midline. The arguments against a midline incision are mainly related to scar formation. We combat this possible feature by the following means: (a) the skin incision is closed by means of a subcuticular Surgiloy suture; (b) the adhesive hemicast used for stabilization reduces skin tension and wound exudate to a minimum and has produced excellent healing results; (c) if the patient is subject to keloid formation, or evidence of the same appears, we radiate the skin in the early postoperative period with a single dose, under the supervision of an expert radio-therapist.

Subperichondrial resection of the deformed cartilages should err on the excess side, and frequently we minimally resect the first normal cartilage above the deformed ones, in order to obtain a better molding of the chest wall to the desired position. Regeneration takes place promptly in the perichondrial layer and the stability of the chest wall returns in a matter of 10 to 14 days. Radical resection of cartilages and the anterior ends of ribs, if indicated, is particularly necessary on the steep side of the slope of the asymmetrical type of deformity in order to obtain a good cosmetic result. Subperichondrial mobilization of the cartilages is facilitated by starting laterally, using a towel clip to elevate the cartilage which has been divided beyond the deformity, and working towards the sternum. Likewise, a towel clip on the xiphoid process after partial division of the xiphisternal junction will improve visibility, aid in elevating the sternum, in order to strip the posterior attachments to the sternum. Complete excision of the xiphoid process results in a significant depres-

sion just below the sternum. It should be retained and covered by the rectus sheath. The lowest ribs and cartilages can be exposed by incisions along the muscle fibres of the rectus abdominus, rather than dividing the insertions.

We endeavor to do a very thorough release of the diaphragmatic attachments to the sternum and to the perichondrium of the lower costal cartilages. With good elevation of the sternum by means of the xiphoid process and keeping initially to the midline, the tissues are carefully divided from the back of the sternum. The sternal attachments of the transversus thoracis are also divided as far upwards as possible with the visualization available. Next, the diaphragmatic attachments to the perichondrium of the sixth and seventh cartilages are stripped off with great care, particularly on the right side, to avoid entering the pleura. We have not encountered a hypertrophied substernal ligament to date. Next, the sternum is elevated in an over-corrected position and any perichondrial layers which act as a tether on the sternum should be severed at the sternal end. Occasionally, in severe deformities, it is also necessary to sever a complete intercostal bundle or bundles, more often the sixth or seventh, in order to obtain satisfactory over correction of the sternum.

In practically all cases, after the age of six years, further mobilization of the sternum is necessary by a transverse V-shaped osteotomy above the level of angulation (of the sternum). This is best done with a gouge and should involve the anterior table and marrow only. In the severe deformities, often two osteotomies are necessary to obtain normal configuration of the sternum. In the younger age group, by means of a sharp cutting needle, two or three sutures of strong silk or linen are placed across the osteotomy to fix it in the corrected position. In the older age group, as fixation of the osteotomy is most important, two drill holes are made above and below the osteotomy for fixation with a nonabsorbable suture in the over corrected position.

We routinely drain the retrosternal space with a No. 14 urethral catheter, brought out through a separate stab incision. This is attached to an underwater seal to which negative suction is applied, and it is usually removed on the second postoperative day. It has the twofold advantage of removing serosanguineous collections of fluid and controlling pneumothorax which might have gone undetected. It also will control a minor pneumothorax produced at operation, until the pleura seals over.

In the procedure of thoracoplasty in the immediate post-war period in Britain, when more anesthetists became available, the operations were done under general anesthesia rather than local. This resulted in more extensive resections, and the problem of paradoxical movement and its ill effects postoperatively was of real concern. We experimented with various forms of maintained padding and orthopedic appliances in the form of a harness. They were either uncomfortable or ineffectual. The most satisfactory procedure we devised to control paradox was the utilization of heavy padding with laparotomy pads, held down by a light plaster cast, which extended around the operated side, over that shoulder and maintained in position by a light band of plaster around the lower

costal margins. This left the sound side free of encumbrance, as in a thoraco-brachial plaster used in war wounds.

Trapp[15] in 1953, to control postoperative paradox in thoracoplasties, introduced a superior method of applying the plaster cast. He used the principle of making the cast adhesive over the area involved in the paradox. We have utilized this method, modified for the particular area of paradox encountered in the operation for pectus excavatum, which, considering the procedure, is gross.

Following a radical mobilization of the deformity by the technique previously mentioned, one or two No. 1 steel sutures are placed under the sternum by means of a large curved needle. These sutures are brought out through an intercostal space, approximately in the mammary line. The number of sutures used depends upon the degree of deformity, whether one or two osteotomies of the sternum have been done, and an estimation, when tension is applied to the suture, if it adequately overcorrects the sternal position. We found that the above method, using the sutures as a sling with a lateral tension produces a better result than drilling holes in the sternum and producing a direct anterior tension.

In the process of closure, sutures of cotton are placed between the perichondrium of the resected cartilages and the under surface of the pectoralis major muscle. This has a two-fold purpose of obliterating dead space, but more important that by having the anesthetist over expand the lungs on application of the plaster, it also maintains the perichondrial beds in a position of overcorrection to enhance the physiological and cosmetic result.

The pectoralis major fascia is approximated in the midline with cotton sutures. The skin is closed by continuous subcuticular Surgiloy sutures. The ends are tied together for ease of removal over a Telfa dressing.

The anterior and lateral chest wall to the posterior axillary folds is now painted liberally with tincture of benzoin, which is allowed to become tacky. The chest is then wrapped transversely without undue tension, with elastoplast. This extends from just below the clavicles, to the lower costal margins and laterally to the posterior axillary folds. Six inch plaster slabs are next applied over the elastoplast, taking care to keep it low enough at the axillary folds to allow free movement of the arms, but high in the infraclavicular area. The plaster is well rubbed into the mesh of the adhesive for good anchorage. One slab thickness with slight overlap is sufficient to establish a firm breastplate. While the cast is being applied, an assistant maintains firm traction on the ends of the wire suture or sutures. Also, we instruct the anesthetist to keep the lungs in a position of over expansion until the plaster becomes firm. The ends of the steel wire or wires are now firmly anchored on the anterolateral surface of the hardened plaster. This is accomplished by wrapping each wire end around two or three wooden tongue depressor blades, all the while maintaining the tension on the wires. The tongue depressors are maintained in place on the plaster breastplate by a further thin plaster slab, so that the tension remains constant. When the hemicast is quite dry, two inch adhesive plaster is applied to the edges and neighboring skin to give additional stability.

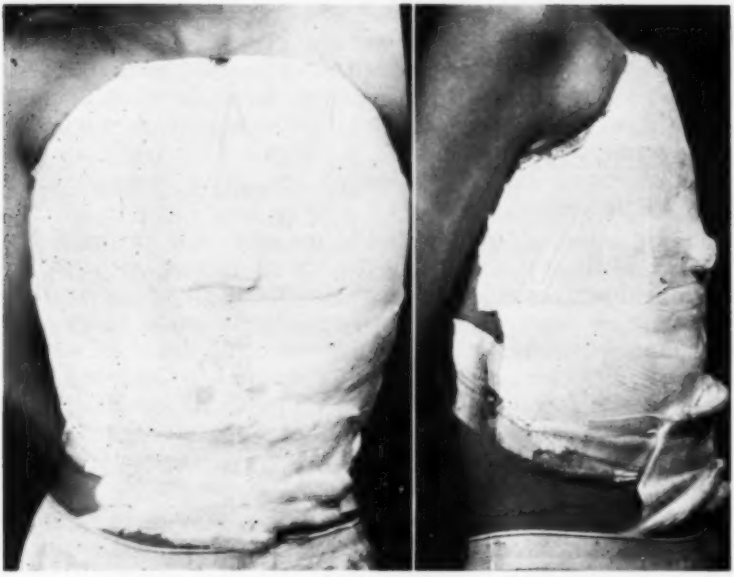


FIGURE 1 FIGURE 2

FIGURE 1: Antero-posterior view of the hemicast following removal of the retrosternal catheter. FIGURE 2: A lateral view of the same hemicast.

The retrosternal catheter is removed on the second postoperative day, provided the chest x-ray film is satisfactory. The patient is allowed out of bed. Specially designed physiotherapy is started on the fourth postoperative day. The cast is removed on the tenth day, as well as the skin sutures. The cast is removed by cutting one end of the wire sling suture, and with a firm pull it comes away usually without the patient's knowledge. The lateral edges of the cast are bent anteriorly and the cast and elastoplast, although always firmly adherent to each other and to the skin, strip off without discomfort to the patient.

There is no evident paradox of the near normal chest wall following removal of the cast. The stability is much more marked than one would expect at a period of ten days postoperatively. This fact is often volunteered by the patient without prompting. The physiotherapy is continued vigorously, aimed at strengthening the pectoralis major muscles, coupled with deep breathing exercises. We encourage adolescents and adults to do a lot of swimming, which is an excellent natural form of physiotherapy for rehabilitation in this condition. We have an arrangement months' course of calisthenics with graduated weights. The results are striking as illustrated in the following photographs. Pulmonary function with a local gymnasium, whereby adolescent boys and men take a three studies have shown conclusively that adequate postoperative physiotherapy is most important to accentuate the physiologic improvement of the respiratory system.

We consider this method superior to other forms of postoperative stabilization of the anterior chest wall for the following reasons:

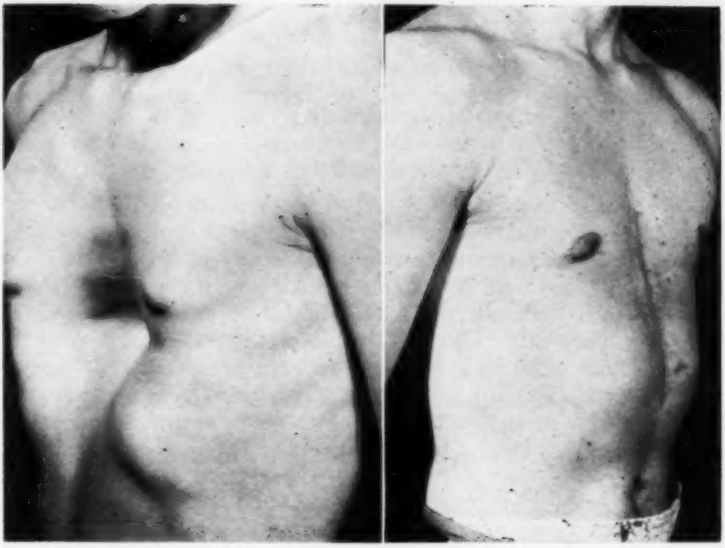


FIGURE 3 FIGURE 4

FIGURE 3: Preoperative photograph showing typical deformity in pectus excavatum.
FIGURE 4: Postoperative photograph of the same case in the early postoperative period following repair.

1) paradoxical respiration is completely controlled and the protective splinting allows efficient coughing and deep breathing exercises in the immediate postoperative period. In our series, there has never been a respiratory complication requiring bronchial suction. The tracheobronchial toilet is looked after by the patient without difficulty; 2) although postoperative pain is present, it is minimal and again it does not interfere with the cough reflex. Early mobilization is achieved without undue discomfort and the patient has a sense of stability and protection of the operative site; 3) the cast reduces skin tension at the operative site to a minimum. It produces excellent healing with an esthetic scar formation. We assume also that it lessens wound exudate, for it has never been present on removal of the cast in this series of cases; 4) plaster of Paris is a well-tried method of fixation on surgery and it maintains better than any other method the results obtained at operation. Fixation of the costal cartilages to the sternum would, theoretically, at least, lessen the chances of cardiopulmonary improvement because of the continued restriction of substernal space. The introduction of bands, wires, pins and bone struts, must carry some hazard of foreign body reaction, and the possibility of infection; 5) there is no difficulty in adapting the hemicast to any type of physique. Large breasts of women do not cause any problem, nor does adiposity; 6) we have been particularly impressed by the value of this technique in the older age group with severe deformities. It allows one to mold the chest as desired after radical resection and to maintain it as such for a good result; 7) this procedure, in our opinion, provides a shorter hospital period, allows earlier mobilization, compara-

tively free of pain, and the introduction of appropriate physiotherapy when it is necessary, as in any major thoracic procedure.

We have found this method of stabilizing an operated pectus excavatum eminently satisfactory in the treatment of over 50 cases of traumatic flail chest.

Results

We have judged our results in the main empirically, on our clinical acumen and the statements of the patients or parents. We admit that neither of these judgments can be statistically accurate. No cosmetic or functional assessment was made earlier than six months postoperatively. Our final assessment of results is: 89 good, 6 fair, 2 recurrences.

The group presenting with severe symptoms constituted the cases in which the most gratifying end results were achieved. This age group ranged from the newborn to 18 years. There were 21 cases in this group and all had symptoms that seriously interfered with their existence. A boy of 16 years in this group, two winters before operation, was able to play on his school ice hockey team. His increasing dyspnea and diminished cardiac output incapacitated him to such a degree that he became unable to attend school, and had to sleep in a semi-Fowler position. His anterior chest wall was reconstructed in the summer of 1955, and in the following winter, he was playing ice hockey again. The patients presenting with lesser disabilities likewise obtain rapid and complete alleviation of their symptoms and often experience a surprising weight gain and sense of well being.

The cosmetic results are more difficult to assess accurately. In the adolescent and older age group, adequate and sustained physiotherapy plays an important role in achieving the desired result and a good posture. Generally speaking, abolition of the deformity, no paradox on inspiration, a good posture and minimal scar formation are the prerequisites for good result. It was noticeable that cases operated on for cosmetic reasons alone volunteered that postoperatively there was a symptomatic improvement of their general well being.

The 96 cases were made up of 77 of the central type, 17 asymmetrical deformities, usually with a rotated sternum, and two cases of pigeon chest. One case of pigeon chest was operated on for cosmetic reasons in a female with good results. The other case had severe asthma which was improved considerably following operative repair. The males outnumbered the females 56 to 40 in this series.

The complications following surgery have been surprisingly few. There was no death or serious morbidity in the 96 patients. We were particularly impressed by the lack of respiratory complications other than that of pneumothorax produced at operation.

Complications which occurred were: nine cases of keloid formation, two minor wound infections, two partial wound disruptions, 11 pleurae opened at operation, one late epigastric hernia, and two recurrences of deformity, requiring re-operation.

When the pleural cavity is entered at operation, we aspirate the entrapped air by means of a urethral catheter and syringe, and the pleura is closed. The substernal catheter plus the negative suction on

the under-water seal adequately looked after this complication, postoperatively. In three cases, however, it was felt expedient to insert a large urethral catheter as well, through an intercostal space, to resolve the pneumothorax.

The two cases of partial wound disrupture due to catgut intolerance occurred early in our series, and with the subsequent use of cotton suture material, this complication has not occurred. The two minor wound infections occurred with the use of silk skin sutures. This has never occurred since using Surgiloy suture material.

Four of the cases of keloid formation were corrected by means of excision, resuture, and skin radiation. The patient who had a late small epigastric hernia from weight lifting, emphasizes the importance of adequately repairing and re-attaching the rectus muscle.

SUMMARY

A method of postoperative stabilization of the chest wall in pectus excavatum has been developed that is both simple and physiologically sound. It produces a near anatomic reformation of the anterior thorax, no matter how severe the deformity, and at the age it presents itself. In addition, the convalescence is smooth, remarkably free of complications, permitting early mobilization of the patient, with comparative freedom from pain or paradox, producing early and late stability of the thorax. In other words, it is a thorough mobilization that can be tailored to the required specifications and maintained as such until adequate healing takes place to produce a stable reformation of the anterior chest wall.

RESUMEN

Se ha ideado un método para la estabilización postoperatoria en pectus excavatum que es al mismo tiempo sencillo y fisiologicamente satisfactorio. Produce una reformación casi anatómica de la pared anterior del tórax sin que impqrte qué tan acentúada sea la deformación o cual sea la edad que tenga. Además la convalescencia es tranquila, notablemente exenta de complicaciones, y permite la movilización temprana del enfermo, libre de dolor y de respiración paradógica comparativamente y que produce una pronta estabilización del tórax. En otras palabras, una completa movilización que puedes ser ajustada a las especificaciones requeridas y que puede mantenerse como tal hasta que haya curación para producir la estable reformación de la pared anterior del tórax.

RESUMÉ

Dans le cas de malformation de la paroi thoracique (thorax en entonnoir) les auteurs exposent une méthode d'immobilisation post-opératoire de la paroi que est à la fois simple et physiologiquement correcte. Elle produit une rénovation presque anatomique du thorax antérieur, quelle que soit la gravité de la déformation, et l'âge auquel elle se présente. En outre la convalescence est douce, remarquablement indemne de complications, et permet une mobilisation précoce du malade, avec une relative absence de douleur ou de difficultés respiratoires et amène une stabilité précoce et tardive du thorax. En d'autres termes, une mobilisation complète, qui peut être adaptée aux cas d'espèce et maintenue telle jusqu'à ce qu'une guérison convenable prenne place et amène un remaniement définitif de la paroi thoracique antérieure.

ZUSAMMENFASSUNG

Eine Methode der postoperativen Stabilisierung der Brustwand, die sowohl einfach als auch physiologisch vernünftig ist, wurde entwickelt. Sie führt eine nahezu anatomische Reformierung der vorderen Brustwand herbei, ungeachtet der Schwere der Deformeirung und des Lebensalters. Ausserdem ist die Genesung auffallend frei von Komplikationen, erlaubt eine frühe Bewegungstherapie des Patienten mit vergleichsweiser Schmerzfreiheit. Mit anderen Worten kann bei einer gründlichen Bewegungstherapie, zugeschnitten auf die erforderlichen Verhältnisse, die aufreshterhalten wird, bis eine hinlängliche Heilung eingetreten ist, mit einer sicheren Reformierung der vorderen Brustwand gerechnet werden.

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CHARACTERISTICS OF LIPOID EXCHANGE IN PATIENTS WITH HYPERTENSIVE VASCULAR DISEASE

The most important indices of lipoid exchange (cholesterol, lecithin, lecithin-cholesterol coefficient and lipoprotein complexes) were determined in 84 patients suffering from hypertensive vascular disease and in 12 healthy subjects.

The observations have shown that hypertensive vascular disease is regularly attended by disturbances of the lipoid exchange. These shifts were most marked in the III stage of the affection. The indices of lipoid exchange may be utilized in the diagnosis of atherosclerotic changes in patients with hypertensive vascular disease and consequently be of importance in timely preventive and therapeutic measures in these patients.

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EXPIRED CARBON DIOXIDE AS A GUIDE

The authors found that the rapid infrared carbon dioxide analyzer can serve as a monitor for production of carbon dioxide and for detecting changes in the functioning of the cardiovascular and respiratory systems during anesthesia and operation. They expressed the view that perhaps one of the most valuable assets of the carbon dioxide analyzer is that it is a continuous monitor, thus revealing far more accurate information regarding the circulation than does the routine, intermittent recording of blood pressure and pulse rate.

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Changes in Ventilation Following Complicated Pulmonary Resections

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When pulmonary resection is prescribed, it is important that the risk of possible complications be determined as accurately as possible. Today, in an aging population, one encounters an increasing number of patients who require little reduction in cardiopulmonary function to render them "pulmonary cripples." Although one encounters much published data concerning the effects of uncomplicated pulmonary resections upon pulmonary function,[1-17] there is little available information regarding the effects of complications. Dietiker and associates[14] reported that one patient with partially relieved bronchospasm and two with partially relieved atelectasis showed no difference in carbon monoxide diffusing capacity when compared to similar uncomplicated cases. Mendenhall and associates[15] found that postoperative complications accounted for excessive loss of function in 22 of 29 patients who were studied because of severe decrease in ventilation following thoracotomy. Nine of these patients had thoracoplasty prior to testing. It is interesting that seven of the 29 had no demonstrable complications. Smith and Siebecker,[16] studying ten patients with postoperative atelectasis found that the blood oxygen saturation improved with voluntary deep breathing as well as relief of atelectasis, suggesting involvement of more than one mechanism. Smith and associates[17] reported no consistent functional change in patients suffering postthoracotomy complications. Many with complications had normal or near normal blood oxygen saturations and greater vital capacities or expiratory flow rates than the group average which included uncomplicated cases. It is then apparent that not only is there little information available regarding the functional effects of pulmonary complications, but there is also no available correlation between the severity of the common complications and the degree of functional change. It is the purpose of this paper to attempt to obtain information regarding these problems.

Choice of Method

Before commencing a study of the functional changes which accompany various postthoracotomy complications it is necessary first to choose a standard of measurement and second to establish a normal "base line."

Vital capacity (VC) pre- and postoperatively was chosen as the standard of measurement since it appeared to be the most accurate after reviewing our experiences and those of others,[4-7,10-13,15,17,18] It is easy to perform and is highly reproducible. It provides an excellent method of following progressively the recovery of ventilation after thoracotomy.[2,6,12,13,15,17] It correlates well with the amount of pulmonary disease preoperatively.[1,5] Although some investigators[4,10,12] report correlation

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of changes in VC postoperatively with the amount of pulmonary tissue resected, most[1-7,11,13,17] have reported similar changes after one to approximately five segments have been removed. Our experience[6] indicates no difference in postoperative changes in VC after removal of one to seven segments and permits us to group together all resections of less than seven segments.

Although timed VC does not change after uncomplicated pulmonary resections,[6,7,17] the test was included in this study to determine whether or not obstruction of the air passages occurred in complicated cases.

A number of investigators[3-6,10-12] have reported positive correlation between the amount of pulmonary tissue excised and postoperative changes in maximum breathing capacity (MBC). Some have suggested that MBC is a more accurate test than VC. However, it has been our experience and that of others[5] that values for MBC vary considerably more than for VC, possibly because MBC is more difficult to perform and dependent upon such factors as patients' condition and muscular strength. Moreover, since MBC requires the use of only a fraction of the VC one would not expect extirpation of as much as a lobe to decrease the pulmonary volume sufficiently to affect the MBC.[10] It appears likely that MBC reflects the general condition of the patient. Since patients who require more extensive operations also frequently have more disease and since trauma tends to be proportionate to the extent of surgery, it is not surprising that average values for MBC sometimes seem to correlate with the size of the pulmonary resection. That such a correlation does not necessarily occur has been shown by Miller and associates,[7] who reported no change in the average postoperative MBC after one to five segments had been removed. Moreover, if MBC is superior to VC

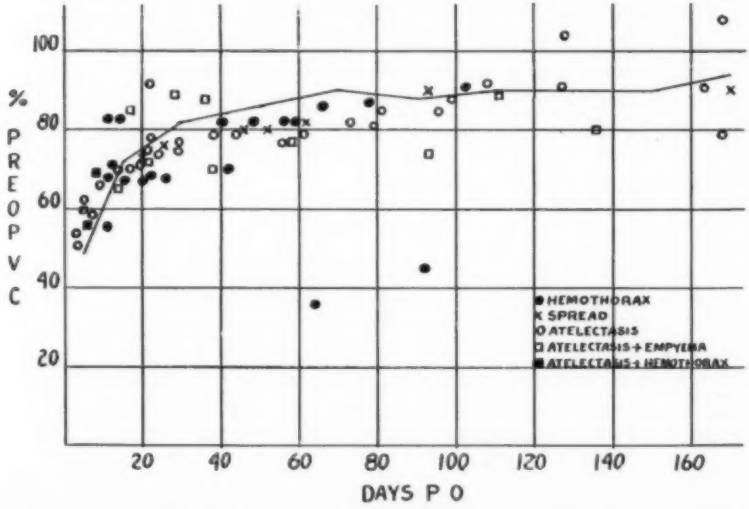

FIGURE 1: Postoperative values for vital capacity expressed as per cent of preoperative values. The continuous line represents the mean values obtained following uncomplicated pulmonary resection. Sixty-seven observations were made upon two patients with "spread," six with hemothorax, six with atelectasis, two with atelectasis and tuberculous empyema, and one with atelectasis and hemothorax.

as a measure of pulmonary ventilatory capacity one would expect the preoperative values to correlate better with the extent of pulmonary disease. Taylor and associates[5] found VC a more accurate measurement of the amount of preoperative disease than MBC. Since maximum expiratory flow rates are depressed postoperatively in the absence of changes in timed VC,[17] it must be assumed that the patients' maximum effort compares unfavorably with his preoperative capacity. This would certainly influence MBC more than VC.

There is no evidence that pulmonary diffusing capacity for carbon monoxide,[14] blood oxygen saturation,[16] total capacity, residual volume,[7] compliance,[8] or intrapulmonary gas mixing[9] yield more accurate information regarding postoperative functional changes than does VC.

As a basis for comparison in this study the average values of postoperative VC from a previously reported series of uncomplicated pulmonary resections[6] is employed in Figures 1 to 3. Deviations from the mean rarely exceeded approximately ± 15 per cent of the preoperative VC.

Vital capacity was performed in the upright position using a modified Benedict-Roth spirometer. Timing was performed with a stop watch. Usually the best of three attempts was recorded.

Material

Since January, 1955, 524 pulmonary resections have been performed at Ray Brook. Almost all of the patients had pulmonary tuberculosis. Except for early in this series, it has been customary to determine timed and total VC preoperatively and at various intervals postoperatively. Occasionally the tests have been omitted when patients could not fully cooperate.

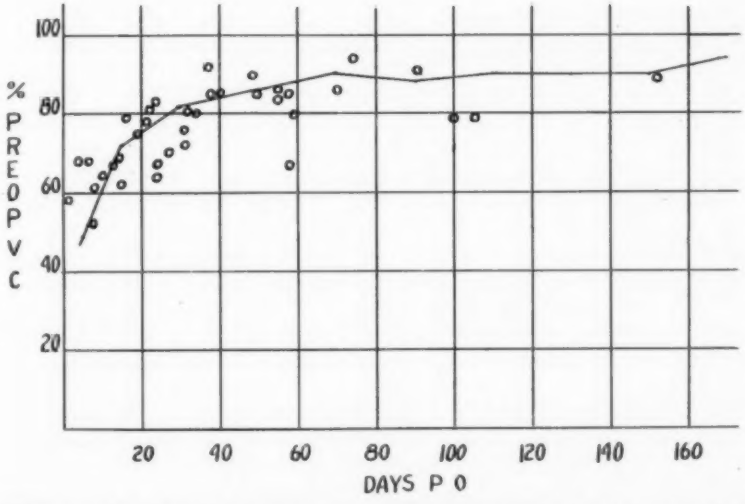

FIGURE 2: Thirty-seven observations made upon 13 patients with postoperative pleural empyema. Values are in the same terms as in Figure 1.

In this series, the following complications occurred after partial pulmonary resection: six atelectases, seven hemothoraces, two "spreads," 21 persistent pleural air spaces, 14 tuberculous pleural empyemas, three non-tuberculous (pyogenic) pleural empyemas, two atelectases with tuberculous empyemas, and one atelectasis with hemothorax. Pleural air spaces were differentiated from empyemas by culturing the contents of cavities. Whenever organisms were recovered from the pleural cavity, the complication was classified as empyema. "Spreads" were manifested by the appearance of new shadows contralaterally in the postoperative roentgenogram. In both instances, the shadows rapidly disappeared. Atelectases were treated vigorously by endotracheal suction and occasionally bronchoscopy, usually with rapid success. In order to eliminate complicating factors, patients were dropped from this study as soon as thoracoplasty was performed in the treatment of pleural air spaces or empyemas. Four patients had thoracoplasty so soon following resection that data could not be used in this study. Three from the early part of this series did not have preoperative studies and one did not have postoperative studies; these patients were also excluded from the study. All of those with the complications listed are alive except one who had tuberculous empyema. This patient died several months postoperatively, but early postoperative ventilatory studies are included in this report.

Generally, complications in this series were not severe; but they represented the type usually encountered. No attempt has been made to eliminate seriously ill patients. Other deaths have occurred, but not in patients suffering from the complications listed above.

Results

Six patients developed atelectasis, four involving one lobe and two an entire lung. Two developed atelectasis in addition to empyema. The

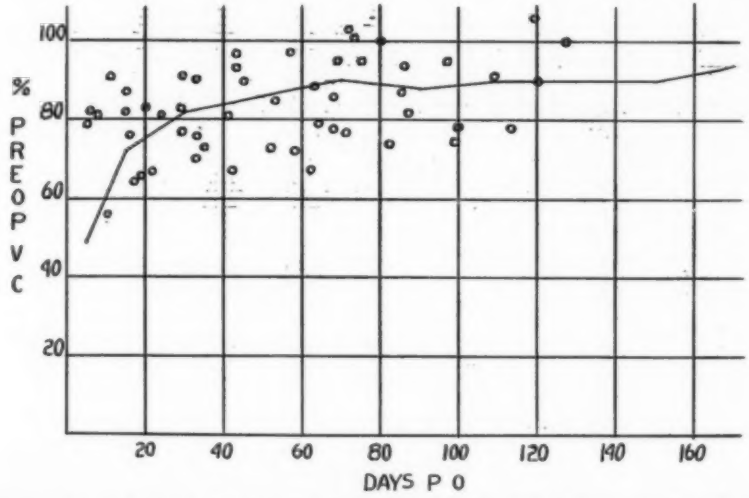

FIGURE 3: Fifty-two observations made upon 18 patients with postoperative pleural air spaces. Values are in the same terms as in Figure 1.

atelectasis involved the whole lung in two instances and one lobe in the remaining patient. All of the empyemas occupied less than approximately 25 per cent of the pleural cavity. One had complete atelectasis of a poorly functioning lung and hemothorax of about 30 per cent. Figure 1 reveals that none of the patients with atelectasis, even those with other complications, demonstrated a considerable deviation in ventilatory function from the expected range. Undoubtedly, this can be explained partially by the fact that atelectases were vigorously treated and early expansion was accomplished in almost every instance. In one with atelectasis of one lung, VC immediately after endotracheal suction was 100 cc. greater than before the procedure. Two days later the VC had increased by another 300 cc. accompanied by radiographic evidence of pulmonary expansion.

Two patients with "spreads" involving no more than 25 per cent of the contralateral lung showed no demonstrable change in VC when compared with uncomplicated cases (Figure 1).

Six cases of hemothorax were studied (Figure 1). The fluid occupied less than approximately 25 per cent of the pleural cavity in four cases. In two the size of the hemothorax was estimated at approximately 25 to 50 per cent of the capacity of the hemithorax. Only one had abnormal postoperative VC (38 and 45 per cent on the 64th and 94th postoperative days). This patient had one of the largest collections of pleural fluid.

There were 13 who developed postoperative pleural empyema (Figure 2). All empyemas occupied less than approximately 20 per cent of the hemithorax. In none of them were postoperative values for VC beyond the limits determined for uncomplicated cases.

Figure 3 summarizes the results in patients with residual pleural air spaces, untreated by thoracoplasty. The spaces occupied less than 25 per cent of the hemithorax in 13 instances and from 25 to 50 per cent in five instances. While values are almost symmetrically scattered about the

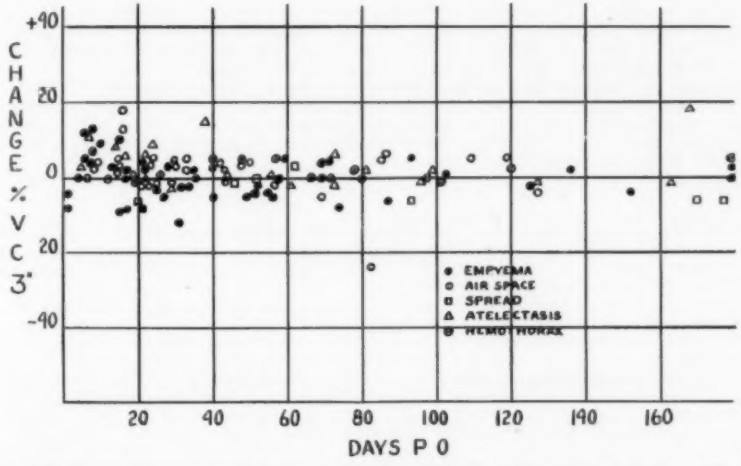

FIGURE 4: Changes in the percentage of total vital capacity expired in three seconds. Postoperative values are expressed in terms of differences from preoperative values. All complications included in this study are represented.

mean for uncomplicated cases, the patients with larger air spaces tended to yield lower postoperative values.

As noted by Smith and associates[17] there was no demonstrable alterations in timed VC postoperatively (Figure 4). From this evidence, one might conclude that there is little obstructive element in the ventilatory changes which occur in the complications reviewed.

Discussion

Immediately after uncomplicated partial pulmonary resection VC decreases to a low level, and recovers over the subsequent few weeks.[6] This decrease in ventilation is due almost completely to restriction of expansion of the lung operated upon.[7] Fluoroscopy confirms this, when it can be shown that the lung is smaller than preoperatively and there is restriction of motion in the homolateral diaphragm and chest wall. This decrease in VC cannot be overcome completely by active attempts by the patient. It seems likely that most of the decrease in VC is the result of "traumatic pleurisy" as it resembles the changes which occur in infectious pleurisy. This assumption is supported by the observations of Gaensler,[1] who reported a considerable decrease in ventilation when the pleura was opened, even after all of the air and fluid had been withdrawn. That chest wall injury does not account to a considerable extent for such ventilatory changes is indicated by the fact that plombage thoracoplasty and extrapleural pneumothorax are accompanied by relatively slight changes in ventilation.[1,6] This theory is also supported by the evidence that ventilatory deficiency is always greater following bilateral pulmonary resection than after unilateral resection of the same extent.[13]

There is much evidence that following both thoracoplasty and resection the decrease in VC is accompanied by a decrease in perfusion of the lung operated upon. Several investigators report a concomitant decrease in oxygen consumption with impaired ventilations.[1,5,7] This is understandable since it has been shown that compression of pulmonary tissue is accompanied by decrease in pulmonary circulation in the collapsed area.[20] Since resection removes part of the pulmonary vascular bed, it is obvious that this will also affect perfusion. Dietiker and associates[14] found that carbon monoxide diffusion capacity and breath holding volumes decreased in the early postoperative period and that both improved with time. Although this might appear to reflect a change in alveolar-capillary membrane permeability, in the light of other evidence it seems more likely that the changes are primarily the result of a decrease in blood circulating through the lung operated upon. Smith and associates[17] have shown that early decreases in arterial blood oxygen saturation are largely the result of hypoventilation and can be corrected by causing the patients to breathe deeply.

Since the lung is frequently distensible beyond the size of the hemithorax it occupies it is understandable that resection of a few segments, especially if diseased, will not of itself exert a restrictive action upon VC. Indeed, even after resection of enough tissue to render the lung smaller than the hemithorax, the opposite lung may mask the ventilatory effects upon the lung operated upon, by expanding with a shift of the mediastinum. Pleural restrictive changes (sometimes referred to as "thoracotomy effect"[4]) may be sufficiently large to mask any changes in function due to small pulmonary resection.[6]

There is no evidence that airway obstruction occurs to an appreciable extent following uncomplicated resection. This is evident from the fact that timed VC does not change postoperatively.[6,17] It has been noted already that MBC does not necessarily reflect the presence of an obstructive element, as it is also dependent upon the patients' ability to perform muscular effort.

Theoretically, one would expect intrapleural accumulations of air, pus or blood to produce similar effects upon respiratory function, and the severity of the change to be proportional to the size of the accumulation. Moreover, one would expect the effect of compression of a poorly functioning lung to be less than the effect of compression of a well funtioning lung.[1] Indeed, it appears from our experience that these changes are exactly what occur. Of course, one does not intend to imply that the presence of infection is no more serious than the presence of air or blood, but merely that in the absence of other complicating conditions such as severe fever or pneumonia the functional changes are similar. This appears to occur most commonly in our experience since spicific antituberculous drug therapy has been almost routinely employed.

"Spread" following pulmonary resection probably represents the presence of secretions in the contralateral air passages. It occurs most frequently when the opposite lung is dependent during surgery.[21] If the sputum is infectious and antituberculosis drug therapy is not administered, pneumonitis may occur in the involved segments. In our experience, the "spreads" were small and cleared rapidly, indicating the absence of gross infection. It is not surprising, therefore, that VC did not differ from the expected. It seems likely that ventilation of the involved pulmonary segments following noninfectious "spreads" can occur by collateral channels.[22] When infection occurs in the involved lung, one would expect a decrease in VC in excess of the expected.[18]

Atelectasis of a portion of lung, even as much as a lobe, may produce little change in VC, as the collapse may be accompanied by compensatory expansion of the remaining lung tissue. Atelectasis of a whole lung does produce a measurable decrease in VC, but much less than 50 per cent. It is not surprising that Smith and associates[17] did not always discover blood oxygen desaturations in their complicated cases since collapse of pulmonary tissue is frequently accompanied by a corresponding decrease in perfusion. However, arterial oxygen desaturation does occasionally occur[16] and this cannot be completely relieved unless atelectasis is successfully treated.

Generally, expansion of pulmonary tissue such as occurs following resection is much better tolerated than collapse. Gaensler[1] found that pneumothorax produced a greater ventilatory deficit than lobectomy and sometimes pneumonectomy. Any agent which produces pulmonary collapse, (including pleural fluid or air, and thoracoplasty) may decrease ventilation not only on the ipsilateral but also on the contralateral side, principally by causing a shift of the mediastinum. Pulmonary resection is followed by little late change in ventilation,[6] even after a considerable amount of pulmonary tissue has been removed.

It is not the purpose of this paper to review the methods of preventing complications following pulmonary resection, as this has been done previously.[21] However, it should be stressed that the degree of functional impairment is proportional to the size of the complications. For this reason every effort should be made to maintain maximum pulmonary expansion and to limit the size of pleural fluid collections postoperatively. Antituberculosis drug therapy should be employed in all pulmonary resections upon patients with infectious tuberculosis. If these precautions are followed, one may expect a low morbidity and mortality as in this series.

SUMMARY

1. Changes in postthoracotomy empyemas, hemothoraces, atelectases, pneumothoraces and "spreads," unless extensive, do not produce severe functional changes.

2. The vital capacity appears to provide one of the most sensitive measurements of these changes.

3. Pulmonary compression is less well tolerated than pulmonary distension.

RESUMEN

1. Los cambios despues de empiemas tratados por toracotomía, o por ,hemotorax, atelectasia, neumotorax y diseminaciones, a menos que sean muy extensos, no producen alteraciones funcionales graves.

2. La capacidad vital al parecer proporciona una de las medida smas sensibles de estos cambios.

3. La compresión pulmonal es menos bien tolerada que la distensión pulmonar.

RESUMÉ

1. Les altérations des épanchements suivant la thoracotomie, des hémothorax, des atélectasies, des pneumothorax, et des "disséminations," à moins qu'elles ne soient extensives, ne produisent pas de troubles fonctionnels graves.

2. La capacité vitale semble offrir une des mesures les plus sensibles pour ces altérations.

3. La compression du poumon est moins bien tolérée que sa distension.

ZUSAMMENFASSUNG

1. Die durch Empyeme, Hämothoraces, Atelektasen, Pneumothoraces und "Streuungen" bewirkten Veränderungen, insofern es sich nicht um solche ausgedehnter Art handelt, führen zu keinen stärkeren funktionellen Beeinträchtigungen.

2. Die Vitalkapazität scheint der empfindlichsten Meßverfahren für diese Veränderungen darzustellen.

3. Eine Kompression der Lunge wird weniger gut vertragen als ihre Überdehnung.

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MARKEDLY ELEVATED BLOOD AMMONIA IN A PATIENT WITH CONSTRICTIVE PERICARDITIS

A markedly elevated blood ammonia level in a patient with chronic constrictive pericarditis is reported. After surgery, with removal of the calcified pericardium from both ventricles and of calcifications from the right auricle and inferior vena cava, the blood ammonia returned to normal. Since no primary liver disease was found, it is presumed that a portal bypass resulted from the constriction in the region of the inferior vena cava.

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Tuberculosis in an Industrial Plant*,**

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Introduction

The occupational health program of a large oil refinery and petrochemical plant incorporates features which aid in the detection of pulmonary tuberculosis.

The periodic examination system which includes a routine chest roentgenogram and which is conducted on all plant employees at 12-24 month intervals would be expected to discover asymptomatic cases. In addition, other cases might be found when appropriate diagnostic procedures are carried out by company physicians on symptomatic workers who report to the dispensary, or on return to work after a period of illness.

Since 1921, there has existed a special tuberculosis benefit program which provides economic security for the patient and his dependents during the prolonged period of disability. The practice of returning patients who recover satisfactorily to appropriate productive work has permitted long-term follow-up.

With this background, it was decided to review those cases of tuberculosis occurring in the employee population of approximately 7500 during a ten-year period.

Method

A list was compiled of all active tuberculosis cases detected during the decade 1949-1958. This was accomplished by a review of periodic examinations, laboratory and x-ray data, and a check of diagnostic codes of sickness absenteeism. All absences due to sickness occurring in the refinery are documented as to cause as follows: (1) workers must report to the Medical Department whenever they become ill on the job, or return for release to work after an illness; and, (2) certificates covering the period of disability are received from the attending physicians. As a further check, the Annuities and Benefits Department provided a list of all those who received sickness benefits under the special tuberculosis benefit program. Data which form the basis of this report were extracted

TABLE 1—AGE DISTRIBUTION OF 40 TUBERCULOSIS CASES

Age Group	Number of Cases in Age Group at Onset of TBC	Per Cent of Cases	Per Cent of Employees in Age Group
20-29	3	7	6
30-39	9	23	27
40-49	14	35	35
50-59	11	28	26
60-65	3	7	6

*From the Medical Department, Humble Oil & Refining Company, Baton Rouge Refinery.

**Presented at the Annual Meeting, Southern Chapter, American College of Chest Physicians, St. Louis, Missouri, October 30, 1960.

from the company medical records, and in certain cases, from outside medical agencies.

Results

Incidence of Tuberculosis. Forty cases of active pulmonary tuberculosis occurred in 37 of the 7500 employees during the ten-year study period, an incidence of 53/100,000 population per year. This compares with an average of 81 for the state of Louisiana for the same interval. All cases were males; 33 were white and four were colored.

Table 1 shows the distribution of the 40 cases according to age at the time the tuberculosis was discovered. Our youngest patient was 24 and the oldest was 64. The average age of all patients was 46 years, while the average age of the whole worker-population was 44.

Detection of Tuberculosis. The manner in which tuberculosis was detected in our population of industrial workers is of interest (Table 2). Thirty-seven cases were discovered by the refinery medical department and three cases were discovered by the personal physician, on examination, in the hospital or clinic. Of the 37 cases discovered by refinery physicians, 27 turned up during the course of routine periodic examinations; only three of the 27 patients were symptomatic. Two cases were discovered on return-to-work examinations following respiratory disease, and eight cases were discovered by the dispensary physician; seven of these eight cases came to the dispensary because of respiratory symptoms. Two of the three cases discovered by outside physicians had respiratory symptoms and the third case was detected during a routine preoperative work-up.

A history of contact with known tuberculosis was obtained in 12 patients. This aspect of history was not aggressively pursued by company personnel, since additional study was carried on by the local health unit.

Confirmation of Diagnosis. Whenever the diagnosis was suspected, appropriate diagnostic measures were carried out; these tests included sedimentation rates, sputum studies, serial x-ray films, skin testing, etc. The diagnosis of tuberculosis was confirmed bacteriologically in 34 of the 40 cases (Table 3). Sputum smears and cultures were positive in 28; gastric washings were positive in five; bronchial washings were positive in one; lung biopsy was positive in three; and laryngeal biopsy was positive in one.

Clinical Status. At the time of discovery, ten cases were classified as minimal, whereas 26 were classified as moderately advanced, two were far advanced, and two were tuberculomas. Cavitation and/or honeycombing were present in 28 cases.

TABLE 2—DETECTION OF TUBERCULOSIS

Number of Cases Detected by	Refinery Medical Department 37 Cases	Personal Physicians, Clinics, Hospitals, Etc. 3 Cases
Periodic Examination	27	0
Return to Work	2	0
Respiratory Symptoms	8	2
Other	0	1

TABLE 3—METHOD OF CONFIRMATION (34 CASES)*

Sputum	28
Gastric Washings	5
Bronchial Washings	1
Biopsy	4

*Some cases were confirmed by more than one method.

Complications of pulmonary tuberculosis were conspicuous by their absence. Although there was one case with established laryngeal involvement, there were no cases with recognized central nervous system, bone, genitourinary, or gastrointestinal tuberculosis.

Inasmuch as company medical policy emphasizes that all definitive therapy is a function of private or community medical resources, all patients were referred to their local physicians for treatment. Most of the patients were hospitalized in the Greenwell Springs Tuberculosis Hospital, a state supported institution. The type of treatment followed the general trend. The ten patients treated with collapse therapy (two pneumothorax, five pneumoperitoneum, and three phrenic crush) occurred early in the series. Those occurring later were treated with drug therapy and four underwent surgical excision of the pulmonary lesion. Many of the recent cases have continued on antituberculous drugs for a year or longer after returning to work.

Work Status. The distribution of the 40 cases of pulmonary tuberculosis among the various job classifications in the refinery is shown in Table 4. Approximately one-third of the patients were engaged in shift work. Thirty-three employees continue at work. The group has worked a total of 171 man-years following rehabilitation. All but three of the 33 employees who returned are working without medically imposed restrictions. One was restricted following a lobectomy and thoracoplasty and the other two are on restricted duty because of deformities resulting from rheumatoid arthritis. There were no employees whose work entailed chronic or recurrent exposure to recognized pulmonary irritants (silica, asbestos, etc.).

Table 5 shows duration of hospitalization and disability absence. It is interesting that 30 of the 40 cases were hospitalized less than 12 months, and 35 of the 40 cases returned to work within 18 months. One elderly

TABLE 4—JOB CLASSIFICATION

Administrative		0
Technical		3
Clerical		4
Skilled		22
Electrical	2	
Storehouse	2	
Pipefitter	4	
Motorized Equipment Operator	1	
Welder	1	
Boilermaker	1	
Instrument Technician	2	
Machinist	1	
Process Operator	8	
Unskilled		11

TABLE 5—DURATION

Months	Hospitalization	Absence from Work
0-6	8	3
6-12	22	16
12-18	8	16
18-24	2	3
24+	0	2

Negro male reached age 65 and was automatically retired while still undergoing therapy for his tuberculosis. The only death that occurred in the series was that of a hypertensive, diabetic, 41 year-old Negro who exsanguinated via the tracheobronchial tree; he had been hospitalized two years. Two elected voluntary retirement after resuming work, their pulmonary condition being arrested.

The benefits paid by the company program, which included funds necessary for subsistence of dependents during the period of disability of the patient, averaged $3,890 per case.

Discussion

The data shown in Table 2 indicate the importance of the periodic examination in the refinery medical department program as related to the early detection of pulmonary tuberculosis; over half of the cases of this study were so discovered while still in an asymptomatic state.

Although only ten cases had minimal lesions, tuberculous complications were absent. The finding of 26 cases in moderately or far advanced stages indicates that even periodic examinations with chest x-ray films at approximately 12 to 24 month intervals will not find all cases in an early or minimal stage. In reviewing this series, one is impressed by the rapidity of progression of tuberculous pulmonary disease in certain cases. For example, one of the cases on routine x-ray examination had no evidence of a lesion, but on a repeat film nine months later had a three cm. infiltrate which was suspected of being a carcinoma; this proved, at surgery, to be a caseating tuberculoma. In another instance, the patient had a barely perceptible lesion which progressed in a period of five weeks to a moderately advanced stage of the disease.

With regard to rehabilitation, the medical recommendation almost invariably was to return the employee to his previous refinery assignment. This offers the best employment situation; the individual knows his work, the short cuts, and feels at home with it.

The present trent is to return patients to their former jobs immediately upon discharge from the hospital. Allen[1] reported a series of 300 such cases with excellent results. Likewise, Wier and Tempel[2] feel that tuberculosis is no indication for excluding personnel from military service. Eighty-three per cent of their cases were retained in active service in excess of two years with a relapse rate of only four per cent. In a study of 326 veterans treated in 1948 and 1949, McKone[3] found that 92.6 per cent were working.

One must be aware of off-the-job activities. It is surprising the number of employees who carry on outside businesses which may be important to the regulation of their over-all activities.

Because of the relatively long period of physical inactivity required during treatment of pulmonary tuberculosis, a benefit program which will carry both patient and those dependent on his earnings through the period of disability to arrest of the disease and rehabilitation at work might seem unduly expensive. However, the investment per case of $3,890 is less than the weighted average annual wage of refinery employees, and is considerably less than the cost of hiring and training a new employee.

SUMMARY

Forty cases of active tuberculosis occurred in 37 employees of a large oil refinery and petrochemical plant during a ten year period. The incidence of tuberculosis was 53/100,000 per year, as compared to a rate of 81 for the state in which the plant is located. None of the affected workers had significant occupational exposure to silica, asbestos, or recognized pulmonary irritants. Thirty-seven of the cases were discovered by the refinery medical staff, three being detected by other physicians. Thirty-three were able to resume work, having accumulated 171 man-years of productive employment at the time this study was terminated. The average cost of rehabilitating a case is significantly less than the cost of hiring and training a new employee.

RESUMEN

Durante el período de diez años, se presentaron cuarenta casos de tuberculosis activa en 37 empleados de una gran refinéria de una planta petroquímica. La incidencia de la tuberculosis fue de 53/100,000 por año, comparada con la proporción de 81 en el estado donde la planta está ubicada. Ninguno de los trabajadores afectados tuvo una exposicion significativa de manera ocupacional a sílice, asbestos o a otros reconocidos irritantes pulmonares. Treinta y siete de los casos se descubrieron por el personal médico de la refinería, habiendo sido descubiertos, tres por otros médicos. Treinta y tres pudieron volver a su trabajo, habiendo acumulado 171 años-hombre de empleo productivo cuando se terminó este estudio. El costo medio de la rehabilitación por caso es significantemente menor que el costo de contratar y adiestrar a un nuevo empleado.

RESUMÉ

Quarante fois on eut à constater une tuberculose active chez 37 employés d'une grande raffinerie d'huile et de pétrochimie au cours d'une période de dix ans. La fréquence de la tuberculose fut de 53 pour 100,000 par an, alors que le taux de l'état où se trouve l'usine est de 81. Aucun des ouvriers atteints n'avait eu d'exposition professionnelle caractérisée à la silice, à l'amiante, ou à des facteurs reconnus irritants pour les poumons. 37 des cas furent découverts par le personnel médical de la raffiinerie, trois l'ayant été par d'autres médecins. 33 furent capables de reprendre leur travail, ayant accompli 171 années ouvriers de travail efficace au moment où l'étude s'est terminée. Le coût moyen pour réadapter un cas est nettement moindre que celui d'engager et d'entrainer un nouvel employé.

ZUSAMMENFASSUNG

Während eines zehnjährigen Zeitraumes ereigneten sich 40 Fälle von aktiver Tuberkulose bei 37 Angestellten einer großen Ölraffinerie und chemischen Fabrikanlage. Die Tuberkulosehäufigkeit lag bei 53/100,000 pro Jahr im Vergleich zu einer Ziffer von 81 für den Bundesstaat, in dem sich der Betrieb befindet. Keiner der betroffenen Mitarbeiter war durch seine berufliche Tätigkeit in beträchtlichem Maße gegenüber Silicium, Asbest oder erkennbare pulmonale Reizstoffe exponiert. 37 Fälle wurden ermittelt durch den ärztlichen Dienst der Raffinerie und 3 durch andere Arzte. 33 waren zur Wiederaufnahme ihrer Arbeit fähig und hatten es zum Zeitpunkt des Abschlusses dieser Untersuchung auf 171 Personen-Jahre produktiver Tätigkeit gebracht. Die durchschnittlichen Unkosten der Wiedereingliederung eines Falles lagen beträchtlich niedriger als der Betrag zur Anwerbung und Ausbildung eines neuen Mitarbeiters.

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HIATUS HERNIA

The modes of presentation as revealed by an analysis of 200 cases indicate the frequency of "reflux." and emphasize the importance of meticulous history-taking in the elucidation of the precise nature of the "pain" of which complaint is made. Blood loss and anemia are shown by this series to be very much more common and very much more severe than is generally realized. Lack of uniform criteria of what constitutes a severe degree of blood loss probably accounts for this incorrect impression. Dysphagia is shown in the series to be related to the size of the hernia or the development of complications such as esophagitis and stricture. Precordial pain is shown to be not as common as is frequently thought. The importance of medical treatment is emphasized and an attempt has been made to place in true perspective the role of surgical treatment. The importance of adopting the best surgical procedure as indicated by the facts in each individual case is emphasized. The great danger of unrevealed tearing of the esophagus in complicated cases is pointed out. The results as indicated in the series appear good and it is claimed these are due to careful selection of cases and meticulous care in surgical details.

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Pulmonary Tuberculosis in Old Age*

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Introduction

Reports from countries with advanced tuberculosis programs reveal a marked shift in the incidence of active pulmonary tuberculosis toward the older age groups, particularly in men. To date only a comparatively few comprehensive studies have been published on the many aspects and implications of the increase of tuberculosis in the aged but all of them stress that this group can become one of the main sources of the spread of tuberculosis, and the consequent danger thereof.

In Israel, a similar shift has been observed as shown by the following tables taken from the Statistical Abstract of the Israel Government for 1957-58. Table 1 shows: mortality by ages per 100,000 population for 1952-1957. Table 2 shows: newly reported cases of active tuberculosis by ages per 10,000 population for 1952-1957.

TABLE 1

	1952	1953	1954	1955	1956	1957
All ages	13.3	10.5	9.1	7.3	6.1	5.1
0-59 years	10.2	7.0	5.3	4.7	3.3	3.1
Over 60 years	53.2	56.0	59.8	40.6	41.0	32.0

TABLE 2

All ages	10.5	10.7	7.9	6.7	5.4	5.8
0-59 years	10.2	10.3	7.6	6.2	5.0	5.5
Over 60 years	14.3	17.7	13.0	12.5	11.2	12.5

This paper, based on a review of 197 aged patients treated over the six-year period 1953 to 1958 in the Malben-JDC Home for Tuberculous Aged at Pardessia B., is intended as a contribution in the following areas:

1. Clinical course of pulmonary tuberculosis in aged.
2. Response of old-age tuberculosis to prolonged drug therapy.
3. Social problems in the management of this group of patients.

The Place—Pardessia B

The Pardessia B. institution was set up as a home for tuberculous aged within the frame of services provided by Malben-JDC, through the American Joint Distribution Committee, to help care for the needy sick, handicapped and aged new immigrants who were arriving in such large numbers in the years after the establishment of the State of Israel in May, 1948.

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‡Institutions of Malben-JDC, the services of the American Joint Distribution Committee in Israel, the funds for which are derived chiefly from American Jewry through the United Jewish Appeal.

The institution, which originally was intended to fulfill the functions of a home for aged rather than that of a hospital, is situated in a rural area surrounded by cultivated lands and orchards. It comprises a number of small buildings, and its bedrooms for the residents can accommodate from two to five persons. One of the buildings contains the medical examination room, an x-ray room, a small laboratory, an occupational therapy unit and space for day activities. The education of the staff was geared to the general needs of aged people, and the physical facilities of the premises were planned toward creating a residential atmosphere for them.

Married patients whose spouses wished to join them in the institution were given separate rooms so that they could live the normal life of married people outside.

All the residents, even those with extensive disease, were encouraged to take part in the daily activities of the institution, as much as was possible and in accordance with their physician's recommendation, in different household tasks around the kitchen, dining room, laundry, garden, office, etc. In addition, they took care of their own living quarters except for the heavy cleaning.

The patients who were not ambulant or required help in the daily activities of washing, dressing, feeding, etc. were accommodated in a separate unit which included a sick bay.

All the residents were under constant medical supervision, and each underwent periodic re-evaluations which included x-ray of the chest, sputum examination and other tests as indicated.

The Patient Material

Of the 197 patients admitted, 186 had had previous treatment before entering Pardessia—151 in tuberculosis hospitals and 35 in chest clinics; while the remaining 11 patients received their first course of treatment in Pardessia. Of the total number, 138 were men and 59 women; and in addition 41 healthy spouses had joined their sick partners.

The reason for admission for the majority was the presence of active pulmonary tuberculosis despite prolonged hospitalization, but it was felt that further stay in hospital would be of no substantial benefit. Furthermore, in view of the prevailing serious economic and social problems in this group, it was feared that these patients could become a serious factor in the spread of tuberculosis if they were to be discharged to the community.

Method

Six years after the initiation of this program a study was carried out to evaluate the clinical results and to determine the advisability of continuing with this type of care.

For each patient in Pardessia at the time of the study a questionnaire was filled out which contained general information and data pertaining to the patient's status on admission, as well as the findings at the time of the study. Questionnaires were filled out also for patients who had been discharged or transferred prior to the study or who had died in the institution. The follow-up of these groups included a review of hos-

pital records, clinical charts, x-ray films, laboratory tests and results of autopsies where available. Further, inquiries were made for the group of discharged patients at the chest clinics where they were under supervision.

Information Obtained from the Study

Some personal and social characteristics of the patients: Of a total of 197 patients, 151 (76 per cent) were more than 65 years of age at time of admission, and of these 83 were in the age groups 70 to 79, and 14 were between 80 and 89.

Twenty-two had been living in Israel before the establishment of the State, and 175 were new immigrants, of whom almost three-fourths hailed from Eastern European countries.

At the time of admission, 75 were married, 107 widowed, 7 divorced and 8 were single. The group of 75 married persons included 4 couples where both partners were suffering from pulmonary tuberculosis, and 41 persons in this group lived with their healthy spouses in the institution.

Movement of Patients

The movement of the patients during the years 1953-1958 and the individual status of each at the time of the study are reflected in Table 3:

TABLE 3

Disposal of Patients	Total	Status at Time of the Study	
		Alive	Dead
Total	197	133	64
Discharged	40	34	6
Transferred to hospitals	32	6	26
Died in Pardessia	32		32
Present in Pardessia	93	93	

At the time of the study 93 patients were still in the institution, while 104 had been discharged during the period covered by the study, 40 of whom went to their own homes or homes for aged, 32 were transferred for various reasons to hospitals, and 32 had died in the institution.

Eighty-eight had been in the institution for more than two years, and of these 31 for more than four years. These long periods of stay made possible a prolonged observation of the course of the disease and of the results of treatment.

The follow-up which was carried out on the patients who had been discharged or transferred extended over periods of time ranging from half a year to three years. It showed that of the group of 40 discharged patients, 34 were alive and six had died; and of the 32 who had been transferred to hospitals, only six were still alive while 26 had died.

Condition of Patients on Admission

Bearing in mind the epidemiological significance of old-age tuberculosis, we considered it important to subdivide the patients into three groups, according to their bacteriological status:

GROUP 1: those whose sputum was repeatedly negative for tubercle bacilli prior to admission.

GROUP 2: those who had history of positive sputum, but whose sputum was negative at the time of admission to Pardessia.

GROUP 3: patients whose sputum was positive for tubercle bacilli on admission to Pardessia despite prior hospital treatment.

Table 4 shows the clinical status of the patients and roentgen manifestations found on admission.

TABLE 4

		Group I	Group II	Group III	Total
CLINICAL*	Unstable	9	13	110	132
Status	Stable-Questionable	23	22	—	45
	Stable	14	6	—	20
	Total	46	41	110	197
ROENTGEN*	Minimal	1	—	—	1
Appearance	Mod. Adv.	42	32	39	113
	Far Adv.	3	9	71	83
	Total	46	41	110	197
CAVITIES	Unilateral	1	7	50	58
	Bilateral	—	—	20	20
	Total	1	7	70	78

*According to classification as approved by the Israel Ministry of Health.

Only 20, according to their clinical status, could be considered stable on admission (sputum negative and no clinical or roentgenological findings of activity for six consecutive months). In 45, the stability of the disease was questioned since the above criteria had been observed for less than six months. One hundred thirty-two had active disease on admission.

Of the total, 113 (57 per cent) had moderately advanced and 83 (43 per cent) had far advanced disease.

Cavities were found in 78 on admission, 70 of whom were in Group III, and of these 20 had cavitation.

Pathogenesis and Clinical Picture

It may be assumed that with increasing age tubercle bacilli harbored from a childhood infection may have died out in some people, and that they may once again have become susceptible to primary tuberculosis. In dealing with this group of aged patients, it seemed important to find out whether we were confronted with recent infections or reactivations of old processes.

There was evidence of active pulmonary tuberculosis between the ages of 15 and 49 in the histories of only 23. In the case of the remaining 174, histories did not yield indications pointing to long-standing disease; however, this cannot be considered proof of a recent infection. The failing memory of the aged and the absence of information from medical sources on the previous health status cast doubt on the reliability of these histories.

Notwithstanding this, we did find in three of the patients clinical manifestations and roentgenological signs pointing to lesions in pathogenetic relationship with a more or less recent primary infection. Two had active middle lobe syndrome, and the third presented a picture of caseous lymph node perforation proved bronchoscopically.

In all the remaining patients, the roentgenological findings were in no way different from those seen in pulmonary tuberculosis of adults, and were probably due to reactivation of old foci. The great variety of roentgenological appearances included small nodular lesions, caseous foci sometimes accompanied by excavations, fibrotic processes, old thick-walled cavities but also recent infiltration and fresh cavitation. In the great majority of the patients bronchial and peribronchial lesions were also present.

Further, the clinical manifestations were similar to those observed in adults of younger and middle age groups, with the difference that the greater proportion of our patients presented symptoms of shortness of breath, more persistent cough and expectoration, mostly due to emphysema and chronic bronchitis or to concommitant heart disease.

It is almost typical for old-age tuberculosis to be associated with a variety of other diseases and ailments which very often overshadow the clinical picture of the primary disease and the signs and symptoms of which are perceived much more acutely by the patient. It is interesting to note that many more patients had to be hospitalized for reasons not connected with their primary disease, and 67 were sent to general hospitals for conditions such as cardiovascular, cerebral, renal and gastrointestinal disorders, and some underwent surgery for prostatectomy, herniectomy, malignancy, etc.

Treatment and Course of the Disease

One hundred thirty-one patients were given antimicrobial treatment during their stay in Pardessia either continuously or intermittently. As a rule, at least two of the main drugs were used in combination in each case.Generally, streptomycin was administered twice a week, while PAS and INH were given daily in adequate doses.

In some cases surgical intervention was indicated but could not be resorted to because of poor general condition, diminished lung function or accompanying disease.

Strict rest regime was not imposed in Pardessia for fear of pulmonary or vascular complications, and because of the psychological effect it might have had upon the patient. Only those with rather severe systemic manifestations were put to bed in the sick bay.

Despite the liberal approach, only 30 had exacerbations or worsening of their condition, and of this number 21 had to be returned to a tuberculosis hospital, while the remaining nine continued with their treatment in the institution.

Generally, it was felt that the concommitant diseases did not influence the course of the primary disease to any tangible degree, but, on the contrary, we noticed the adverse effect of hemoptysis in cases of coronary insufficiency or other heart diseases. Furthermore, the decreased lung function resulting from pulmonary tuberculosis caused an additional deterioration in aged patients who at the same time were suffering from other chronic pulmonary diseases, such as emphysema, chronic bronchitis and bronchiectasis.

Of the 64 patients who died in the institution or after being discharged, the cause of death in 39 was not connected with the primary

disease, but was due to cardiovascular disease, renal disorders, malignancies, etc.; whereas, in only 25 of the cases was death due directly to pulmonary tuberculosis (10 cases), or diseases complicating the primary disease, particularly heart failure due to cor pulmonale (15 cases).

Condition of Patients at the Time of the Study

Change of Clinical Status: The clinical status of the 197 patients at the time of the study is shown in Table 5.

TABLE 5

	Total	Group I	Group II	Group III
Worse	30	2	2	26
No Change	62	15	9	38
Improved	105	29	30	46
Total	197	46	41	110

Only 30 patients became worse during their stay in the institution. Two, whose condition on admission was assessed as questionably stable, appeared to have an unstable process at the time of the study; in the remaining 28 whose condition was unstable on admission, further deterioration was observed, and 19 of them died because of tuberculosis.

In 62 no change was observed; in 20 of these, the condition was stable on admission. In the remaining 42 whose condition on admission was unstable, the signs of activity persisted without clinical or roentgenological changes.

In 105 improvement was noted. Clinical and/or roentgenological improvement was observed in 16, although they continued to have active diseases; in 89, the pulmonary process became stable—in 46 the condition on admission was unstable, in 43 questionably stable.

Change in Roentgen Appearance

The x-ray examination at the time of review showed a spread of the processes in 27, all but one belonging to Group III, as per Table 6:

TABLE 6—CHANGE IN ROENTGEN APPEARANCE

	Total	Group I	Group II	Group III
Worse	27	—	1	26
No change	128	42	33	53
Improved	42	4	7	31
Total	197	46	41	110

In 128 patients there was no change in the roentgenological appearance. Many presented fibrotic changes, nodular lesions or caseous foci. Though not much roentgenological change could be expected in these patients, clinical improvement and sputum conversion was observed nevertheless in many of them. In 42 there was marked improvement, and cavity closure was attained in 14 of them, two of Group II and 12 of Group III.

Change in Bacteriological Status

Only in two did the bacteriological examinations reveal deterioration during their stay in Pardessia, as per Table 7.

TABLE 7—CHANGE IN BACTERIOLOGICAL STATUS

On Admission	At Time of Study	Total	Group I	Group II	Group III
Negative	Positive	2	1	1	—
Positive	Positive	72	—	—	72
Positive	Negative	38	—	—	38
Negative	Negative	85	45	40	—
	Total	197	46	41	110

Seventy-two patients continued to have tubercle bacilli in their sputum after periods of drug therapy varying from less than one year to six years. Of the 110 who entered Pardessia with sputum positive for tubercle bacilli, 38 obtained sputum conversion. In 85 whose sputum was negative for tubercle bacilli on admission, no bacteriological deterioration occurred. This group included 40 whose sputum was positive for tubercle bacilli during their hospital stay prior to admission to Pardessia.

Healthy Partners

Spouses of 41 patients joined them in the institution and lived together with them for periods ranging from one to six years. This study concerned also the health of these spouses during their stay here. It is most interesting to note that none of them contracted active disease in spite of very close and constant contact with the patients. This is true also for four "healthy" spouses who suffered from diabetes mellitus.

Discussion

Studies published by different clinicians (Bloch,[1] Huppert,[2] Kinsella[3]) stress that tuberculosis in the aged essentially is not different from tuberculosis in younger individuals. Beresford[4] and Dufourt[5] state that the frequency of primary infection in old age is a rare occurrence, and that pulmonary tuberculosis in this group is essentially due to reactivation of old foci.

In our material, the histories obtained from the group of 197 patients, the roentgenological appearance of the lesions, and the clinical course of the disease support the views expressed by other authors. Except for three cases of lymphnode perforation and active middle lobe disease, all the others revealed the picture of pulmonary tuberculosis commonly found in the adult. Similar to findings reported by Wraith and Ovens,[6] we too have noted, apart from the usual clinical manifestations, a greater frequency of cough, expectoration and dyspnea.

Perhaps the most striking difference in the clinical picture in our material, compared with patients of younger age groups, was the high incidence of associated diseases not connected with their specific pulmonary processes. Fifty-eight per cent of our patients had one or more associated diseases; and of all the patients who died up to the time of the study, the cause of death was not connected with the primary disease in 61 per cent of the cases. As stated by Bloch, the old tuberculous patients nowadays die with, rather than of, their pulmonary processes.

It has been pointed out in most of the available literature that there is no essential difference between the results of modern drug therapy in elderly people and those in other age groups Huppert, Wraith and Ovens, Russchen and Zalman[7] obtained sputum conversion in from 50 to 70 per cent of their cases. The conversion rate in our group was not as favorable. However, whereas the above authors deal with an unselected group of aged patients treated in hospital, a number of whom underwent chest surgery with good results, our material represents a special group of patients who did not qualify for chest surgery, a great many of whom had made only little progress in spite of prolonged hospital treatment prior to entry to Pardessia, and of whom 45 per cent were above the age of 70.

In our study, clinical stability was attained in 89 (50 per cent) out of 177 patients who had active disease or whose disease was questionable stable on admission to Pardessia, and sputum conversion was achieved in 38 (35 per cent) of 110 patients whose sputum was positive for tubercle bacilli on admission to the institution. It must be noted, however, that the above rates of sputum conversion and clinical stabilization reflect only the results obtained during treatment at Pardessia. The overall results of drug therapy must be measured against the clinical status of these patients at the onset of the disease long before they entered Pardessia.

It appears that of our group of patients, 187 had active pulmonary tuberculosis or their condition could not be considered stable, and of this group 150 had initially tubercle bacilli in their sputum. At the time of this study, the disease had become inactive in 96 patients, and in 78 of them sputum conversion was attained. These end results reveal that in over 52 per cent of our case load clinical stability and sputum conversion have been achieved.

It is important to add that in eight patients, sputum conversion was obtained within two to three years after treatment, in six within three to four years, and in two more only after about six years of treatment. Therefore, it would seem advisable to persist with the treatment of patients who, after what might seem an adequate period of hospital care, continue to have active pulmonary tuberculosis, since sputum conversion may still be attained in some of them after a number of years.

This approach raises the problem of where to continue with the treatment of these elderly people who, because of their active disease, are a danger to the community. Naturally, these patients could be returned to their homes providing suitable economic and social conditions exist, and they had a good understanding of the disease, knew how to safeguard others in the family from infection, and remained under supervision and care of a nearby chest clinic. In the absence of these provisions, the feasibility of their return to the community should be questioned. However, it is obvious that prolonged hospitalization with all the hardships entailed, that is, separation from family and friends, the atmosphere of the sick room, the strict order of a hospital discipline, all undoubtedly may contribute to the feelings of loneliness, frustration and resignation, especially in the aged patient who in his declining years has his specific emotional and social problems. For this reason, treatment should be continued in an institution of a residential character.

We have learned from our experience in Pardessia that many hardships could be spared these patients by allowing them a more liberal way of life, privacy, free social contacts with their fellow residents, and allowing them to participate in the everyday activities of the institution. It was indeed gratifying to see the married patients living happily with their healthy spouses from whom they had had to be separated during their whole hospital stay. This was even more true in the several cases where both partners had tuberculosis and were able to live together; whereas, in hospital they would have had to be in separate wards. It was our impression, based on prolonged observation, that emotionally these patients were much more relaxed, and that this way of life had a beneficial influence on the course of their disease.

SUMMARY

1. This article describes a follow-up made on 197 aged patients who had been admitted, because of pulmonary tuberculosis, to a residential institution during the years 1953 through 1958.

2. All the residents remained under close medical supervision and most of them continued to obtain antimicrobial treatment. At the same time they were encouraged to take part in the daily activities of the institution.

3. The clinical-pathological picture of the disease essentially was not different from that observed in younger age groups.

4. In over 52 per cent of the patients, clinical stability and sputum conversion had been achieved.

5. None of the 40 healthy partners who had lived with their sick spouses in the institution contracted clinical tuberculosis.

6. After an adequate period of hospital care, the aged patient with active disease should be transferred for further treatment to a residential unit when his return to the community is precluded.

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RESUMEN

1. Este artículo describe el seguimiento de 197 ancianos que se admitieron por tuberculosis pulmonar a una institución residencial durante los años de 1953 a 1958.

2. Todos los residentes permanecieron bajo una supervisión médica estrecha y la mayoría de ellos continuaron con tratamiento antimicrobiano. Al mismo tiempo fueron animados para participar en las actividades diarias de la institución.

3. El cuadro clínico y patológico de la enfermedad no fué esencialmente diferente del observado en los grupos jóvenes.

4. En mas de 52 por ciento de los enfermos la estabilidad clínica y la conversión de los esputos se obtuvo.

5. Ninguno de los 40 cónyuges sanos que habían vivido con sus cónyuges enfermos en la institución contrajo tuberculosis clínica.

6. Después de un periodo adecuado de tratamiento hospitalario los enfermos ancianos con tuberculosis activa deben ser enviados a una unidad residencial cuando su retorno a la comunidad no es aceptado.

RESUMÉ

1. Cet article expose les résultats de l'étude complète de 197 malaces âgés, qui ont été admis pour tuberculose pulmonaire dans une institution résidentielle pendant les années 1953 à 1958.

2. Tous les résidents demeurèrent sous une surveillance médicale très suivie, et la plupart d'entre eux continuèrent à prendre les médications antibacillaires. En même temps, ils furent encouragés à prendre part aux activités quotidiennes de l'institution.

3. L'aspect clinique de la maladie ne se montra pas différent de celui que l'on observe chez des malades plus jeunes.

4. Chez plus de 52% des malades on a obtenu une stabilité olinique et une disparition des bacilles.

5. Aucunne des quarante personnes bien portantes, vivant avec leurs époux malades, n'ont contracté la tuberculose.

6. Après une période convenable de soins à l'hôpital, les malades âgés atteints de tuberculose évolutive, doivent être transferrés pour la continuation du traitment, dans un institut résidentiel spécialisé, lorsqu'ils ne peuvent pas revenir dans la vie courante.

ZUSAMMENFASSUNG

1. Diese Veröffentlichung beschreibt eine Nachuntersuchung an 197 bejahrten Patienten, die einer Lungentuberkulose wegen während der Jahre 1953 bis 1958 in eine Art Altersheim eingewiesen worden waren.

2. Alle Insassen standen unter genauer ärztlicher Kontrolle, und die meisten erhielten auch weiter eine antimikrobielle Behandlung. Gleichzeitig wurde ihnen nahegelegt, an den täglichen Beschäftigungen des Heimes teilzunehmen.

3. Das klinisch-pathologische Krankheitsbild war nicht wesentlich verschieden von demjenigen, wie man es bei jüngeren Altersklassen beobachten kann.

4. Bei über 52% der Patienten konnte eine klinische Stabilisierung und Bazillenfreiheit erreicht werden.

5. Keiner der 40 gesunden Partner, die mit ihren Kranken Ehepartnern im Heim zusammen-gelebt hatten, erkrankten an einer klinischen Tuberkulose.

6. Man sollte den bejahrten Kranken nach einer angemessenen Zeitspanne eines Krankenhausaufenthaltes auch mit aktivem Befund zur weiteren Behandlung ruhig in ein Alterheim verlegen, wenn seine Rückkehr in die freie Offentlichkeit ausgeschlossen ist.

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PROGNOSIS IN CARDIAC ANEURYSMS

The issue sets forth the results of observations on 100 patients with cardiac aneurysm for the period 1952-1960. Seventy-four patients died. The most dangerous period for the patient with aneurysm of the heart is the first year following myocardial infarction which led to cardiac aneurysm. Among the immediate causes of death, cardiac insufficiency occupies the first place (one-third of all cases), recurrent acute myocardial infarction rates second, whereby thromboembolic complications and rupture of acute cardiac aneurysm are encountered more rarely. Persons engaged in manual labor prevail among those who survive longer. Rational exercise therapy is conducive to longevity in persons suffering from aneurysm of the heart.

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The Chest Diameter as a Diagnostic Tool*

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The expressions "barrel chest" and "increased antero-posterior diameter of the chest" are frequently encountered in physical diagnosis. These terms are often considered indicative of emphysema.[1,2] Several authors[3,4] feel, however, that barrel chest is not found exclusively in emphysema and that it may be part of the natural aging process. One group[4] points out that in the older ages patients with barrel chests do not show any more emphysema than those without the change. These authors feel that senile emphysema probably does not exist as a separate disease entity. The purpose of this study is to compare chest measurements of patients in an active cardiopulmonary clinic with those of personnel examined in an employees' health clinic.

Materials and Methods

The study was carried out in both clinics during the years 1958 and 1959. The patients were accepted for the study as they reported to the clinic with no other criteria for selection. The actual data was collected by physicians in both clinics. The measurements were made with the calipers used to measure patients for chest roentgenograms. The antero-posterior diameter was measured from just below the sterno-manubrial junction to the level of the sixth dorsal vertebra. The lateral measurements were made 6 cm. under the axilla avoiding the pectoralis major muscle in muscular patients. The breasts of women were not included in the antero-posterior measurements. The measurements were taken in the resting (end expiratory) position. The chest index described by Hurtado *et al.*[5] was used. This consists of dividing the antero-posterior by the lateral diameter of the chest and multiplying by 100 (A.-P/Lat. x 100). Two hundred patients were studied, 100 from each clinic.

Results

The results are shown in Table 1. The majority of the patients in the cardiopulmonary group had emphysema, chronic bronchitis or bronchiectasis. Boeck's sarcoid was also seen (four patients) as were kyphoscoliosis (two patients) and obesity with hypoventilation (one patient).

The persons in the employees' health clinic included healthy individuals reporting for annual or pre-employment physical examinations (69 per cent) and a smaller group who had a variety of minor illnesses. None had apparent chest disease.

The mean age in the cardiopulmonary group was much higher than in the health clinic. There were more men in the cardiopulmonary group; the women predominated in the health clinic. Neither the age nor the sex distribution is unusual since emphysema occurs more commonly in older men.[2]

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TABLE 1—CHEST INDICES IN AND EMPLOYEES' HEALTH CLINIC AND A CARDIOPULMONARY CLINIC

			Health Clinic 100 Persons	Cardiopulmonary Clinic 100 Persons
Sex	Men		33	65
	Women		67	35
Age	Mean		35.6 yrs.	58.5 yrs.
	Range		16-84 yrs.	17-85 yrs.
Chest Index	Mean		71.95	83.8
	Range		59-138	62-125
Chest Index under 45 yrs. of age	Mean		70.8	74.0
	Range		59-138	62-108
Chest Index corrected for sex	Men	Mean	74.5	84.0
		Range	61-138	62-125
	Women	Mean	70.6	83.0
		Range	59-90	62-120

The results seen in Table 1 show that the mean chest indices were higher than those reported by Hurtado[5] (Table 2). The measurements of the present study were made in the resting position and those of Hurtado were taken in deep inspiration. If Hurtado's figures were corrected to the resting position they would be somewhat lower. Many physicians were involved in the study and it seems unlikely that all of them measured in exactly the same way. However, the mean results are remarkably close.

In order to evaluate the difference in age between the patients in the two clinics, the chest indices of patients under 45 years of age were compared. In the health clinic group 71 cases were below 45 years of age whereas in the cardiopulmonary group only 21 cases were in this range. The age corrected data showed little difference in the health clinic group but in the pulmonary group the mean index fell to 74 (Table 1). The effect of the predominance of men in one clinic and women in the other clinic was also studied. Except for a slight rise in the mean index for the men health clinic group no sex difference was present.

Discussion

Although there is a difference between the mean chest indices of the two groups the ranges are almost identical (Table 1). Older men seem to have higher mean indices in both groups, but this slight difference is even less evident in the ranges. Since there is a wide range in all groups, a low chest index does not exclude chest disease, nor does a high index establish its presence. There may be characteristic differences in the chest configuration of patients with emphysema and chronic pulmonary dis-

TABLE 2—CHEST INDICES IN NORMAL MEN AND PATIENTS WITH EMPHYSEMA. HURTADO *et al.*[5]

	50 Normal Men	26 Cases Emphysema
Mean	68.5	79.3
Range	67.95-60.05	77.83-80.77

ease. The lung residual volumes in the emphysematous patients of a cardiopulmonary clinic are high. Some of this increased volume is accommodated by depression of the diaphragms. The rest, however, must influence the size of the thoracic cage. The error lies in concluding that an increase in the lung residual volume invariably causes an increase in the antero-posterior diameter of the chest. The chest index is not a reliable diagnostic sign in an individual case and an increased antero-posterior diameter has limited value as an isolated sign.

SUMMARY

Two hundred cases were studied with respect to the antero-posterior and the lateral diameters of the chest. The quotient of these values was expressed mathematically as the chest index. One-half of the individuals were healthy employees on routine visits to an employees' health clinic and the other half had a variety of chest diseases observed in a cardiopulmonary clinic. Even when corrected for age and sex differences, the difference between the chest indices of the two groups was not sufficient to warrant using the index as a reliable diagnostic sign of emphysema.

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RESUMEN

Se estudiaron doscientos casos con respecto al diametro antero-posterior y lateral. El cociente de estos valores se expresó matemáticamente como el índice torácico. La mitad de los individuos eran empleados sanos en visita de rutina a una clínica de salud de empleados y la otra mitad tenía una variedad de enfermedades del pecho observadas en una clínica cardiovascular. Aún corregida en razon de edad y sexo, la diferencia entre los índices de los dos grupos no fue suficiente para tener como útil el índice para el enfisema.

RESUMÉ

L'auteur étudie dans deux cents cas le diamètre antéro-postérieur et latéral du thorax. Le quotient de ces valeurs est exprimé mathématiquement pour constituer l'indice thoracique. La moitié des sujets était des employés bien portants examinés à l'occasion d'une visite médicale systématique, et les autres étaient atteints d'une des maladies observées dans une clinique cardio-pulmonaire. Même une fois corrigée selon les variations d'âge et de sexe, la différence entre les indices thoraciques des deux groupes n'a pas été suffisante pour permettre l'utilisation valable d'un tel indice pour le diagnostic d'emphysème.

ZUSAMMENFASSUNG

Es wurden 200 Fälle hinsichtlich ihres anterior-posterioren und lateralen Thoraxdurchmessers untersucht. Der Quotient dieser Werte wurde mathematisch als der Brustkorbindex ausgedrückt. Die eine Hälfte der Untersuchten waren gesunde Angestellte im Rahmen eines routinemässigen Besuches einer Ambulanz, und die andere Hälfe bestand aus einer Vielzahl von Thoraxerkrankungen, wie sie in einer Herz-Lungen-Klinik zur Beobachtung kamen. Auch nach erfolgter Korrektur hinsichtlich der Altersund Geschlechts-Differenzen, reichten die Unterschiede des Brustkorbindex zwischen beiden Gruppen nicht aus, als daß sie seine Verwendung als ein brauchbares diagnostisches Zeichen für ein Emphysem gerechtfertigt hätten.

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Pulmonary Tuberculosis in Contacts: A Ten Year Survey*

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No one doubts that the examination of contacts of pulmonary tuberculosis is a case-finding method of great value, but there are conflicting opinions (Aspin,[1] Loudon *et al.*[2]) about the length of time over which it is profitable to continue surveillance if the initial examination is negative.

In order to throw more light on this matter, the names and addresses of 200 people notified in 1948 as having pulmonary tuberculosis were obtained from the records of the Glasgow Health and Welfare Department, and an attempt was made to ascertain the incidence of disease in the household contacts of these patients over a ten-year period. There was no selection of patients except that representative numbers were drawn from successive age groups from 15 years upwards. Of the 200 cases, 23 were discarded because their records did not show unequivocal evidence of active disease. In the remaining 177, the last known residence of the patient was visited to obtain the names, ages, and subsequent addresses of those who were in the household when the disease was discovered in 1948, and information about their health thereafter. This information was obtained from surviving patients or from relatives, and was satisfactory in 155 cases. In order to find out if contacts had been notified up to 1958, their names and addresses were then searched for in the tuberculosis records of the Glasgow Health and Welfare Department. In some cases this information was requested from health authorities outside Glasgow. Statements from relatives about the incidence of tuberculosis in contacts were checked in this way in each of 155 households eventually included for analysis.

Results

The age and sex distribution of the 155 patients discovered to have pulmonary tuberculosis in 1948 is shown in Table 1.

Table 2 shows the age and sex distribution of the household contacts. There were 664 persons in the households of the 155 patients when the disease was diagnosed. Eighty-one (12 per cent) of the 664 household contacts developed active tuberculosis in the ten years following the discovery of the signal case. (More than 81 household contacts had been notified as having contracted tuberculosis in the ten-year period, but after perusal of the records it was decided that the disease was unequivocally active only in these 81). Of the 81 household contacts with active tuberculosis, 61 had adult-type pulmonary disease, 12 had childhood-type primary pulmonary disease necessitating hospital treatment, and eight had non-respiratory tuberculous disease. Of the 664 household contacts, 61 (9.2 per cent) therefore developed active adult-type pulmonary tuberculosis in the ten-year review period.

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TABLE 1—SIGNAL CASES—DISTRIBUTION BY AGE AND SEX

Age (Years)	15-24	25-34	35-44	45-54	55-64	65-74	75+	Totals
Males	21	13	19	9	11	2	0	75
Females	40	24	9	7	0	0	0	80
Totals	61	37	28	16	11	2	0	155

Table 3 shows the distribution by age at 1948 and by sex of the 61 contacts who developed active adult-type pulmonary disease, 29 (8.7 per cent) of 334 men, and 32 (9.7 per cent) of 330 women. The peak age incidence of disease in males was in the age group 15 to 24 years. The peak age incidence for women was in the age groups 15 to 24 years and 25 to 34 years and the rates were similar in these groups. Disease did not develop in women aged more than 44 years (79 at risk), but occasional cases were found in men in all age groups right up to the 65 to 74-year age group.

Table 4 shows how many cases of pulmonary tuberculosis were discovered in household contacts in each year of the ten-year review period; the sexes are shown separately. About one-third (22) of the total 61 cases were noted in the first year, about one-half (32) in the first two years, and about three-quarters (46) in the first five years. Proportionately more women than men developed disease in the first year—about one-half (14 of 32) compared with about one-quarter (8 of 29). In men, therefore, there appeared to be a longer latent period than in women between exposure to infection and development of disease. This is also illustrated by comparing the proportion of disease developing in men and women in the second half of the ten year period—38 per cent in men (11 of 29) compared with 12½ per cent in women (4 of 32).

After five years, the pick-up rate in females dropped considerably and levelled off. The average annual incidence of active disease in women contacts over the age of 15 years in the second five years of the observation period was 2.9 per 1,000 (4 of 273); the incidence of active pulmonary tuberculosis in adult women in the general population of Glasgow in 1957 was 2.8 per 1,000 (Glasgow's X-ray Campaign Against Tuberculosis, 1957). In men contacts, the pick-up rate levelled off by the end of the second year. The average annual incidence of active disease in men contacts over the age of 15 years in the last five years of the observation period was 7.7 per 1,000 (11 of 285); the incidence of active pulmonary tuberculosis in adult men in the general population of Glasgow in 1957 was 4.8 per 1,000 (Glasgow's X-ray Campaign Against Tuberculosis, 1957[3]). It will be seen, therefore, that after five years the incidence of active tuberculosis in adult women contacts approximated that in women in the general population, and that in men contacts the incidence continued at a higher level than that in the general population right to the end of the ten-year observation period.

TABLE 2—CONTACTS—DISTRIBUTION BY SEX AND AGE (YEARS) AT 1948

Age (Years)	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	Totals
Males	31	81	84	44	38	27	18	11	0	334
Females	29	73	67	35	47	46	22	10	1	330
Totals	60	154	151	79	85	73	40	21	1	664

TABLE 3—DISTRIBUTION BY AGE AT 1948 AND SEX OF ACTIVE ADULT-TYPE PULMONARY TUBERCULOSIS IN 61 HOUSEHOLD CONTACTS

Age (Years)	Males Number at Risk	Males Number Developing Disease	Males Per cent	Females Number at Risk	Females Number Developing Disease	Females Per cent
0- 4	31	—	—	29	—	—
5-14	81	5	6.2	73	8	11
15-24	84	13	15.5	67	13	19.4
25-34	44	3	6.8	35	8	22.9
35-44	38	5	13.2	47	3	6.4
45-54	27	1	3.7	46	0	—
55-64	18	1	5.6	22	0	—
65-74	11	1	9.1	10	0	—
75+	0	—	—	1	0	—
Totals	334	29	8.7	330	32	9.7

Tables 5 and 6 show when active tuberculosis was discovered in successive age groups in women and men contacts. Tuberculosis was not diagnosed in women contacts aged more than 44 years at the beginning of the observation period; 79 of the 330 women contacts were in this age group. In girl and women contacts aged five to 24 years at the beginning of the period disease appeared in the first five years if it appeared at all; 9 (43 per cent) of the 21 cases in this category were discovered in the first year and 13 (62 per cent) in the first two years. In boys and men contacts aged five to 24 years, disease made its appearance throughout tracted pulmonary tuberculosis, and eight (44 per cent) of the 18 conthen ten-year period; in all, 18 (11 per cent) of these 165 contacts contracted it in the second half of the ten-year period.

In women aged 24 to 44 years there was sometimes a considerable latent period between exposure to infection and detection of disease; 4 (36 per cent) of the 11 in this age group developed active disease in the second half of the observation period. In men aged 25 years and over there was again often a considerable latent period; 3 (27 per cent) of the 11 in this group developing disease were picked-up in the second five-year period.

It has been suggested that there is often a hereditary susceptibility to tuberculosis (Puffer,[4]). We therefore compared the incidence of active pulmonary tuberculosis during the ten-year period in household contacts who were blood relatives of the signal cases with the incidence in the household contacts who were not. The incidence in blood relatives was 9.4 per cent (51 of 542), and the incidence in contacts who were not blood relatives was 8.2 per cent (10 of 122). The difference in these figures is not striking, especially as there were relatively fewer susceptible 15 to 24 year-olds among contacts who were not blood relatives since spouses comprised a high proportion of their number. However, although

TABLE 4—INTERVAL IN YEARS BETWEEN 1948 AND THE DEVELOPMENT OF PULMONARY TUBERCULOSIS IN 29 MALE AND 32 FEMALE HOUSEHOLD CONTACTS

Years	1	2	3	4	5	6	7	8	9	10	Totals
Males	8	4	1	2	3	1	3	2	3	2	29
Females	14	6	2	2	4	0	2	1	0	1	32
Totals	22	10	3	4	7	1	5	3	3	3	61

TABLE 5—TIME OF DEVELOPMENT OF ACTIVE ADULT-TYPE PULMONARY TUBERCULOSIS IN FEMALE HOUSEHOLD CONTACTS OF DIFFERENT AGE GROUPS

Age (Years)	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	Totals
1 year		3	6	4	1					14
2 years		2	2	1	1					6
3 years		1	1							2
4 years			2							2
5 years		2	2							4
6 years										0
7 years				1	1					2
8 years				1						1
9 years										0
10 years				1						1
Totals	0	8	13	8	3	0	0	0	0	32

there did not appear to be any striking general susceptibility in blood relatives, there did appear to be a well-marked susceptibility in particular families; in one family all five children contracted disease from a parent, and in another family with four siblings, three contracted disease from the fourth.

Discussion

Apart from the high incidence of disease in contacts over the ten-year period, a striking point which emerges from the results of the investigation is that a substantial proportion of the pulmonary disease discovered was found at a time distant from the initial exposure to infection—one-quarter of it was brought to light in the second half of the ten-year review period. In this connection it is necessary to point out that in the majority of cases, disease was detected not as the result of continued routine radiological surveillance, but because investigation seemed clinically desirable. Had regular radiography been carried out, the onset of disease would therefore have been detected earlier in many cases. Nevertheless, it is felt that the results of the investigation give a broad indication of when disease is likely to develop in contacts; in the vast majority of cases there was no suggestion of chronicity in the radiologic appearances, and the fact that similar disease was detected later in young men than in young women suggests that it did in fact develop later.

In connection with this late development of disease in certain contacts, it might be suggested that infection was perpetuated in the household either by its persistence in the signal case or by the subsequent development of disease in other contacts, so that in fact the relevant exposure to infection did not occur at the beginning of the review period, but perhaps at a much later time. The persistence of infection was estimated in 32 signal cases in each of whose households only one contact developed disease. In 14 instances the signal case remained infective for more than two years (in six of them for the entire ten-year period) and four (28 per cent) of the 14 contacts developed disease in the last seven years of the survey. In 18 instances the

TABLE 6—TIME OF DEVELOPMENT OF ACTIVE ADULT-TYPE PULMONARY TUBERCULOSIS IN MALE HOUSEHOLD CONTACTS OF DIFFERENT AGE GROUPS

Age (Years)	0-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+	Totals
1 year		2	2	1	2		1			8
2 years			2	2						4
3 years					1					1
4 years			1					1		2
5 years		1	2							3
6 years			1							1
7 years		1	2							3
8 years			2							2
9 years			1		1	1				3
10 years		1			1					2
Totals	0	5	13	3	5	1	1	1	0	29

signal case became non-infectious in less than two years and disease developed in eight (44 per cent) of the 18 contacts in the last seven years of the survey. The figures are too small, of course, for the findings to have statistical significance, but at least they give no support to the theory that continuing infection could explain the late development of disease. Besides, if this explanation were correct, it would follow that since young male contacts tended to develop disease later than young women contacts, infection in their homes persisted longer—a most unlikely proposition.

The variation in the interval between exposure to infection and development of disease among certain groups is important in relation to the optimum period of contact surveillance. In women under the age of 25 years, disease appeared within five years if it apeared at all; moreover two-fifths of it was detected in the first year, and two-thirds of it in the first two years of the review period. In men of the same age group, on the other hand, only a little over one-half of the disease eventually discovered came to light in the first half of the ten-year review period; in the first year one-fifth of it was detected, and in the first two years one-third. In this group the highest pick-up rate was in the first year, and thereafter disease appeared at a fairly uniform rate right to the end of the observation period: moreover, there is no reason to suppose that further cases will not arise. Although proportionately less disease was discovered in men over the age of 25 years of age than in younger men, the same tendency to latency was manifest, a tendency which was also evident in disease in women aged 25 to 44 years when first in contact with infection. In women over 44 years of age when first in contact with infection (79 at risk) disease did not appear at all.

It would appear, therefore, from the findings of this investigation that it would be profitable, in this area at least, to supervise women contacts under the age of 25 years for five years; women contacts aged 25 to 44 years for ten years or until they reach the age of 45, whichever is the shorter period; and men contacts for a minimum period of ten years; for women contacts aged more than 44 years an initial chest x-ray film would suffice. Long-term regular supervision of contacts, however, presents formidable practical difficulties and at best can only limit and not prevent further dissemination of infection. It is suggested ,therefore, that chemoprophylaxis for household contacts is worthy of serious consideration, particularly when it is borne in mind that with the declining prevalence of tuberculosis in the general community, infection will tend more and more to concentrate in family groups.

SUMMARY

The incidence of tuberculosis in 664 household contacts of 155 people discovered to have active pulmonary tuberculosis in 1948 was investigated. Over a ten-year period 81 (12 per cent) of the 664 contacts developed active tuberculosis; eight (1.2 per cent) non-respiratory tuberculosis, 12 (1.8 per cent) childhood-type primary pulmonary tuberculosis necessitating hospital treatment, and 61 (9.2 per cent) adult-type pulmonary tuberculosis.

Of the 61 cases of adult pulmonary tuberculosis, about one-third (22) were discovered in the first year, about one-half (32) in the first two years, and about three-quarters (46) in the first five years. In women contacts aged less than 25 years in 1948, all the disease detected was found in the first five years, but in men contacts and in women contacts aged 25 to 44 years in 1948, disease continued to appear throughout the ten-year period. Of 79 women contacts aged more than 44 years in 1948, none developed disease. These findings suggest that women contacts aged less than 25 years should be supervised for five years, that women contacts aged more than 44 years need no supervision beyond an initial x-ray film, and that other classes of contacts should be supervised for ten years at least.

Long-term supervision still presents many practical difficulties, and at best can only limit and not prevent dissemination of infection. Chemoprophylaxis for contacts also presents difficulties, but it is suggested that its potential advantages seem so great that a trial is indicated.

RESUMEN

La incidencia de la tuberculosis entre 664 contactos convivientes de 155 personas enfermas de tuberculosis activa en 1948, fue objeto de esta investigacion.

Despues de mas de 10 años, 81 (12 por ciento) de los 664 contactos desarrollaron tuberculosis activa; ocho (1.2 por ciento) presentaron tuberculosis no respiratoria; doce (1.8 por ciento) tuberculosis de forma infantil y necesitaron hospitalización y 61 (9.2 por ciento) tuberculosis tipo adulto.

De los 61 casos de tuberculosis tipo adulto, como un tercio (22) se descubrieron dentro del primer año, la mitad aproximadamente (32) dentro de los primeros dos años, y tres cuartos (46) en los primeros 5 años. En los contactos mujeres de menos de 25 años de edad en 1948, todas las tuberculosis descubiertas se encontraron en los primeros 5 años pero en los contactos masculinos de 25 a 55 años en 1948 la enfermedad continuó apareciendo a través de los 10 años.

De 79 mujeres contactos de mas de 44 años en 1948 ninguna se dessarrolló la tuberculosis.

Estos hallazgos sugieren que las mujeres contactos menores de 25 años deben ser vigiladas por 5 años; que las mujeres mayores de 44 años no necesitan vigilancia mas allá de la película inicial y que los otros contactos deben ser vigilados por lo menos 10 años. La vigilancia a largo plazo aún ofrece dificultades prácticas y cuando mas, limita, pero no previene, la diseminación de la infección. La quimiprofilaxis para los contactos también presenta dificultades pero se sugiere que sus ventajas probables parecen bastante grandes como para que valga la pena ensayarla.

RESUMÉ

L'auteur étudie la fréquence de la tuberculose chez 644 personnes vivant en contact sous le même toit que 155 malades ayant eu une tuberculose pulmonaire active en 1948. Sur une période de dix ans, 81 (12%) des 644 individus en contact ont développé une tuberculose active, 8 (1,2%) une tuberculose extra-pulmonaire, 12 (1,8%) une tuberculose pulmonaire primaire, du type de celle de l'enfant, nécessitant une hospitalisation et 61 (9,2%) une tuberculose de l'adulte.

Sur les 61 cas de tuberculose pulmonaire de l'adulte, a peu prés un tiers (22) ont été découverts dans la première année, environ la moitié (32) pendant les deux premières années, et trois-quarts (46) pendant les cinq premières années. Chez les femmes ayant été en contact et âgées de moins de 25 ans en 1948, toutes les affections découvertes l'ont été dans les cinq premières années mais chez les hommes et chez les femmes âgés de 25 à 55 ans en 1948 la maladie a continué à apparaitre au cours des dix années suivantes. Sur les 79 contages féminins âgés de plus de 44 ans en 1948, aucune n'a été atteinte. Ces résultats prouvent que les femmes âgées de moins de 25 ans ayant été en contact doivent être surveillées pendant cinq ans, tandis que les femmes âgés de plus de 44 ans n'ont pas besoin de surveillance après la première radiographie, et que les autres catégories doivent être surveillées pendant au moins dix ans. La surveillance à long terme présente beaucoup de difficultés pratiques, et le mieux est de limiter la dissémination de l'infection. La chimioprophylaxie présente des difficultés, mais les avantages semblent si grands qu'on doit en tenter l'essai.

ZUSAMMENFASSUNG

Es wurden Untersuchungen über die Häufigkeit des Auftretens einer Lungentuberkulose bei 664 unter Kontrolle stehenden Personen angestellt, die mit 155 an aktiver Lungentuberkulose Erkrankten im gemeinsamen Haushalt Kontakt haben. Die Erkrankung wurde bei den 155 Tuberkulösen 1948 festgestellt.

Nach 10 Jahren hatte sich bei 81 der 664 Personen (=12%) eine aktive Tuberkulose entwickelt. Von diesen bestand bei 8 (=1.2%) eine extrapulmonale Tuberkulose, bei 12 (=1.8%) eine primäre, stationär behandlungsbedürftige Lungentuberkulose und bei 61 (=9.2%) eine Lungentuberkulose v. Erwachsenentyp. Von diesen 61 Fällen wurde bei 22 Patienten die Tuberkulose im ersten Jahr festgestellt, bei 32 Patienten in den ersten 2 Jahren und bei 46 Patienten in den ersten 5 Jahren. Bei allen Frauen unter 25 Jahren, die häuslichen Kontakt mit Tuberkulösen hatten, trat die Tuberkulose in den ersten 5 Jahren auf. Bei Männern und Frauen im Alter zwischen 25 und 55 Jahren konnte das Auftreten einer Tuberkulose über die ganzen 10 Jahre verteilt beobachtet werden. Bei 79 unter Kontrolle stehenden Frauen, die 1948 bereits über 44 Jahre alt waren, trat in keinem Fall eine Tuberkulose auf. Hieraus wird gefolgert, dass Frauen unter 25 Jahren, die durch tuberkulöse Angehörige exponiert sind, über einen Zeitraum von 5 Jahren kontrolliert werden sollten. Bei Frauen über 44 Jahren ist eine Überwachung nicht erforderlich. Es soll lediglich bei der tuberkulösen Erkrankung eines Angehörigen eine Röntgenaufnahme angefertigt werden. Andere Gruppen von Exponierten sollten längstens 10 Jahre in Überwachung stehen. Bei der Langzeit-Kontrolle bestehen zahlreiche Schwierigkeiten, ebenso bei der Chemoprophylaxe. Der Vorteil erscheint jedoch so gross, dass entsprechende Versuche unternommen werden sollten.

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A Design for Inhalation Therapy

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The purpose of this presentation is to describe a parallel piped oxygen and piped compressed air system for use in inhalation therapy, in patients with chronic pulmonary disease.

Intermittent positive pressure breathing (IPPB) with nebulized bronchodilator has been utilized widely in the treatment of conditions associated with disturbances in respiration. Subjective benefits and functional improvement have been reported to occur incident to this mode of therapy.[1-4] Wu and her associates[5] demonstrated that the greatest and most prolonged improvement of ventilatory function in patients with severe chronic pulmonary insufficiency or with excessive secretions was obtained by this method as compared with other methods of aerosolization.

Bronchial drainage is promoted by IPPB as a result of the rapid release of inspiratory pressure at the beginning of exhalation with a peak instaneous inspiratory flow velocity.[6] That the effectiveness of compressed

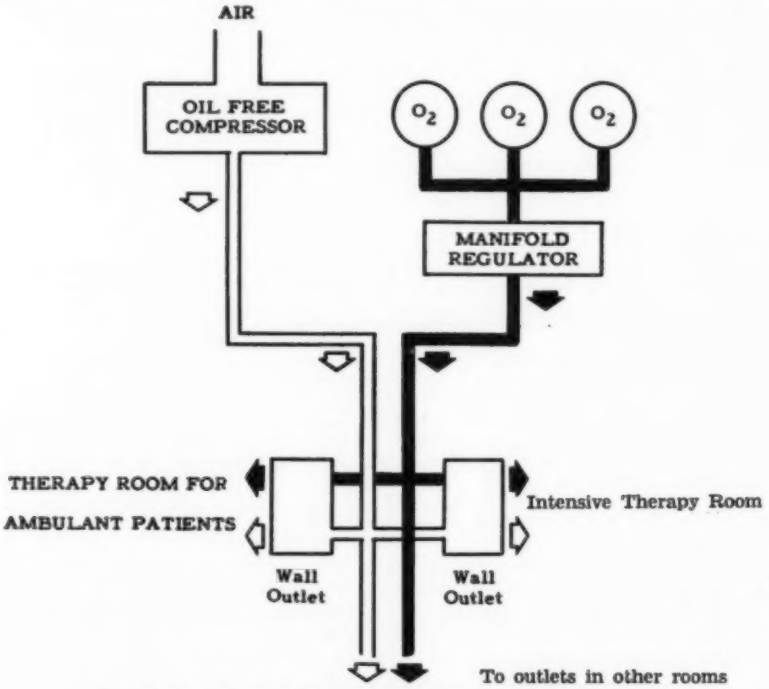

FIGURE 1: Plan of piped compressed air-oxygen system.

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TABLE 1—EFFECTS OF IPPB THERAPY (20 min.)

Gas Used	No. of Pts.	Arterial O_2 Sat. (per cent) Before	Arterial O_2 Sat. (per cent) After	Arterial CO_2 Tension (mm. Hg.) Before	Arterial CO_2 Tension (mm. Hg.) After
Oxygen	22	73	96	52	46
Compressed Air	15	77	83	57	48
30 per cent Oxygen (approx.)	5	70	93	61	51

air-activated IPPB in promoting gas exchange is related to increased ventilation even when an aerosolized bronchodilator is not simultaneously administered has been well demonstrated by Jameson and his co-workers.[7]

Fowler *et al.*[8] concluded that oxygen-aerosolized isoproterenol (Isuprel) was superior to oxygen-intermittent positive pressure breathing alone and was as effective as the combined use of oxygen positive pressure and nebulized isoproterenol. Unfortunately, carbon dioxide contents or tensions were not measured in their study. These authors, however, recommended the use of IPPB in patients with marked hypoxemia and carbon dioxide retention.

Cullen and his co-workers[9] have noted clinical worsening with increased hypoventilation in some patients with carbon dioxide retention, when oxygen is employed to activate the IPPB apparatus. This has been noted by the present authors to occur in the presence of carbon dioxide narcosis.

Adjacent to the nontuberculous pulmonary disease section at the authors' hospital are a 3 H.P. pump and an oxygen manifold.†† Filtered (activated charcoal) compressed air is delivered in copper tubing at

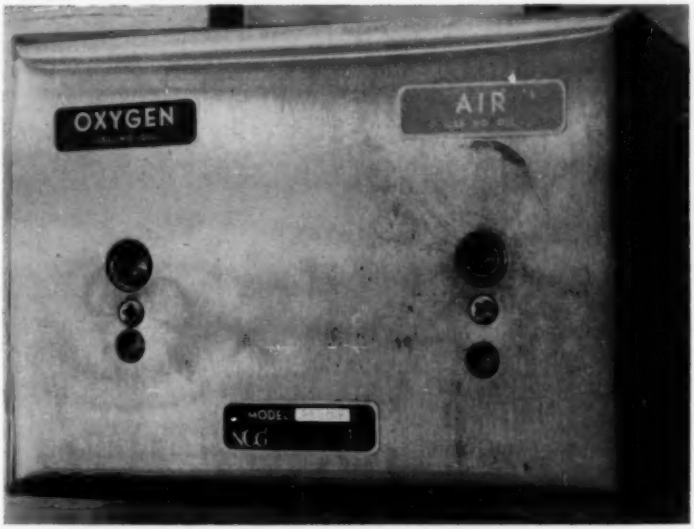

FIGURE 2: Wall-box with compressed-air and oxygen outlets.

††An NCG (National Cylinder Gas Company) Evenflow Control Unit Model 242-4 Manifold System.

approximately 70 pounds per square inch pressure. The oxygen is also piped through parallel tubing to wall-box type outlets in the various rooms (Fig. 1). Thus, each wall-box contains an outlet for oxygen and for compressed air (Fig. 2).‡ The compressed air outlets are employed for positive pressure breathing therapy (Fig. 3) and for suctioning by means of Venturi-type attachments. The oxygen outlets may be used for conventional therapy or to supplement compressed air-activated IPPB when hypoxemia is not readily controlled by this therapy or by measures designed to improve the airways (nebulized detergents or enzymes, exsufflation, bronchoscopy, and occasionally, tracheostomy). This is done by attaching the tubing leading to the nebulizer to a regulator plugged into an oxygen outlet (Fig. 4).

The advantages of this system may be summarized as follows:

1. Improved patient care: the difficulties involved in securing adequate humidification when dry oxygen is employed have been well documented elsewhere.[19] It is estimated that approximately 25 per cent of atmospheric humidity is delivered at the level of the wall outlets. Nevertheless, main-stream nebulization is employed, as recommended by Cushing and Miller,[19] particularly when treating tracheo-

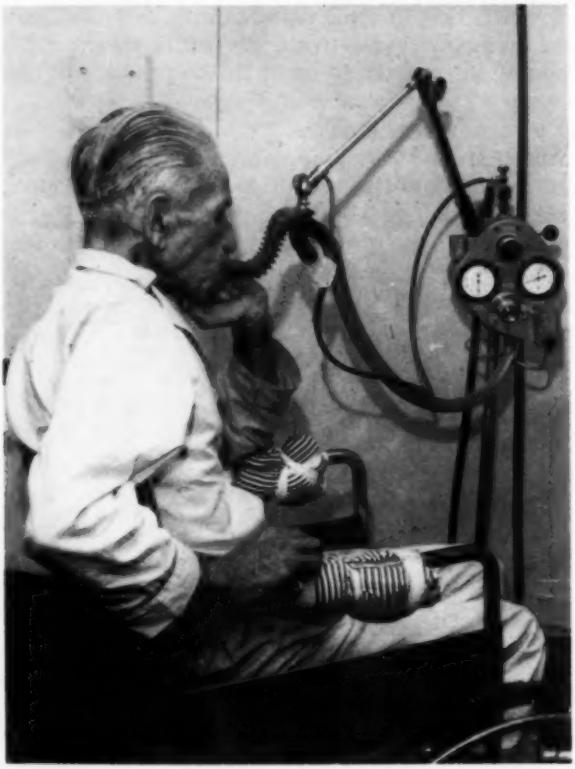

FIGURE 3: Compressed air-activated IPPB therapy.

‡NCG wall-box type outlets, adaptors, connecting hoses, and suction attachments.

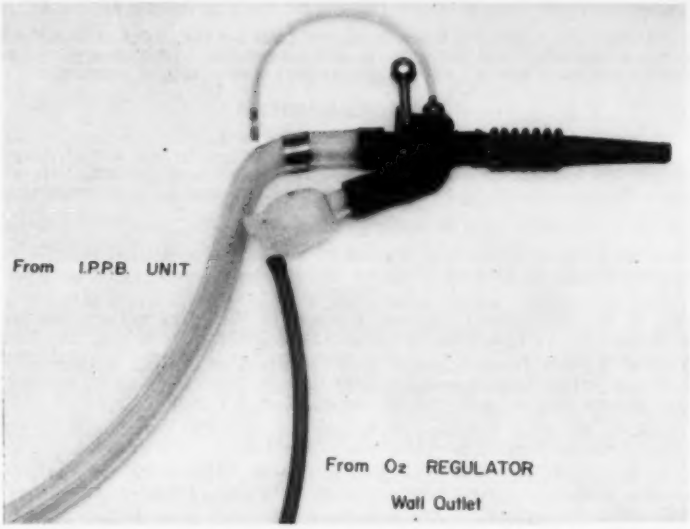

FIGURE 4: Oxygen-compressed air dilution for IPPB therapy.

tomized patients. In the authors' laboratory, 15 hypoxemic and hypercapneic patients exhibited an average rise of the arterial oxygen saturation from 77 to 83 per cent, and an average decline in the arterial CO_2 tension from 57 to 48 mm. Hg. after 20 minutes of compressed air-activated IPPB (Table 1). When oxygen is delivered through the nebulizer as indicated in Fig. 4, a mixture of approximately 30 per cent oxygen is delivered with an average rise in the arterial oxygen saturation from 70 to 93 per cent and a decline in the arterial CO_2 tension from 61 to 51 per cent as determined in five severely ill patients.

2. Safety and convenience: the bulky oxygen tank mounted IPPB units have been replaced by light-weight portable stands supporting these units, with elimination of noise, confusion, danger of oxygen tanks at the bedside and psychologic disadvantages to the patient.
3. Economy: the cost of compressed-air cylinders is prohibitive for routine use. Individual air-compressor driven IPPB units are noisy, particularly when several are simultaneously in use on the same floor. With the elimination of oxygen-activated IPPB, considerable savings have resulted. This can be readily appreciated when one considers the very high rates of flow (up to 130 liters per minute) delivered by the Bennett apparatus.

SUMMARY

A parallel piped compressed air and oxygen system for use in a chronic pulmonary disease section is described. The advantages in terms of improved patient care, safety, convenience, and economy are summarized.

RESUMEN

Se describe un aparato con tubos paralelos de oxígeno y aire comprimido para usarse en los enfermos con enfermedades pulmonares crónicas.

Se hace un resumen de su ventaja para la mejoría del enfermo, la seguridad, conveniencia y economía de su funcionamiento.

RESUMÉ

L'auteur décrit un système à tubes parallèles pour air comprimé et oxygène destiné au traitement des affections pulmonaires chroniques. Les advantages se résument en amélioration des soins donnés au malade, sécurité, commodité et économie.

ZUSAMMENFASSUNG

Es wird ein durch parallele Röhren geleitetes System mit kombinierter Luft und Sauerstaff zur Verwendung auf Abteilungen mit chronischen Lungenkrankheiten beschrieben. Die Vorteile in Form einer besseren Versorgung der Kranken, größeren Sicherheit, Bequemlichkeit und Wirtschaftlichkeit werden kurz zusammengefaße.

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SPONTANEOUS ESOPHAGO-BRONCHIAL FISTULA FORMATION SURGICALLY TREATED IN A 90 YEAR-OLD

Successful surgical treatment of an esophago-bronchial fistula in a 90 year-old woman was accomplished with survival of the patient almost six years later at the time of this report. In view of a 59 to 88 per cent mortality rate recorded in conservatively treated cases and an 11.4 per cent mortality rate in surgically treated cases, the desirability of surgical treatment in even the poor-risk patient is emphasized. The fact that successful surgery of this type can be accomplished even in an aged patient presenting an extremely poor risk because of extensive cardiovascular disease is illustrated by this case. It is thought to involve the oldest patient undergoing successful surgical treatment for this condition recorded to date.

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Bronchial Washings in the Diagnosis of Lung Cancer*

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Since Hempeln,[1] in 1918, first reported tumor cells in the sputum of patients with lung cancer, a number of investigators[2,3,5] have confirmed the value of cytological examination in the diagnosis of this disease. Using techniques developed by Papanicolaou,[4] diagnosis of sputum cytology has been very accurate. Farber, *et al.*,[3] reported 90 per cent accuracy in the positive diagnosis of lung cancer when five or more sputum specimens were examined. They also pointed out that this degree of accuracy declines sharply when the number of specimens is decreased. Despite the high degree of accuracy of diagnosis by sputum cytology, there remains a group of patients in whom other diagnostic techniques are necessary. This study was undertaken to determine the value of saline bronchial washings obtained at the time of bronchoscopy and to compare the incidence of positive sputum and bronchial washings with the ability to visualize the lesion bronchoscopically.

Methods and Materials

During the year 1959, 97 patients with proved bronchogenic carcinoma underwent bronchoscopy at the Roswell Park Memorial Institute. In all cases, bronchial washings were obtained at the time of brohchoscopy. A simple technique of instilling 5 cc. of isotonic saline solution into the appropriate bronchus, as indicated by the x-ray film examination, followed by aspiration and collection of as much of this material as possible, was utilized. The specimens were immediately taken to the Cytology Laboratory where a direct smear of the washings was made and, where possible, a cell block was prepared from the remaining material. Smears were stained by a modified Papanicolaou technique and were examined for tumor cells. Satisfactory samples were obtained in all cases. Only those specimens showing tumor cells were considered positive. That is to say, when atypical cells were found, the specimen was considered to be negative for tumor cells.

Sputum cytology studies were carried out in a large number of these same patients. Sputum was collected in fixative and a cell block prepared from the specimen. Three specimens was considered an adequate examination although a larger number would probably have yielded a higher incidence of positive findings. Many cases had inadequate sputum exam-

TABLE 1—TUMOR CELLS IN BRONCHIAL WASHINGS ACCORDING TO POSITION OF LESION

	Pos. Washings	Neg. Washings	Total
Bronchoscopically Visible	28	22	50
Not Bronchoscopically Visible	4	43	47
Total	32	65	97

*From the Departments of Surgery and Pathology, Roswell Park Memorial Institute and the University of Buffalo School of Medicine.

ination because the diagnosis was established by some other means, such as lymph node biopsy, before three specimens had been submitted for examination. Once the diagnosis was established, further sputum cytology was not done.

Results

The results are summarized in Table 1. It will be noted that in slightly more than one-half of the cases, it was possible to visualize the neoplastic lesion through the bronchoscope. This is a higher incidence than usually noted and may be a reflection of the advanced stage of disease of the majority of these patients. In 28 cases (56 per cent) tumor cells were found in the bronchial washings obtained at the time of bronchoscopy. However, in the 47 cases in which it was not possible to see the lesion via the bronchoscope, quite different findings were encountered. In only four of these cases were positive bronchial washings obtained. In three of the four with positive bronchial washings in the bronchoscopically not visible group, tumor cells were found in examinations of the sputum.

Sputum cytology was more productive of positive findings as can be seen in Table 2. In the group where it was not possible to visualize the lesion bronchoscopically, 14 of 24 patients (58.3 per cent) who had an adequate number of specimens studied were found to have tumor cells in the sputum. In the bronchoscopically visible group, 20 of 28 patients (71.4 per cent) adequately studied had positive sputum for tumor cells.

Discussion

The value of sputum cytology in the diagnosis of lung cancer has been well established. This study shows the incidence of positive sputa for tumor cells to be definitely greater in the more centrally occurring lesions if one uses bronchoscopic visualization as the measure of location. It is not surprising then that positive bronchial washings are much more common when the lesion is bronchoscopically visible. In the peripheral lesions, it would seem unlikely that the saline irrigant could reach the lesion with such force as to cause separation of cells. Cells which have been desquamated and lie free in the bronchus could be suspended in the saline solution and give a positive washing. However, if there are desquamated cells free in the bronchus, adequate sputum studies should yield a positive result.

The results would indicate that adequate sputum studies are superior to bronchial washings in the diagnosis of peripheral lung cancers. Since the incidence of positive washings is so low in the peripheral lesions, one must be extremely cautious in the interpretation of negative results. More than the usual number of sputum samples should be obtained in order to establish the diagnosis. The value of bronchoscopy in this disease is unquestioned. This is amply demonstrated by the large percentage of lesions which were bronchoscopically visible. However, bronchoscopy has its limitations, and one of these occurs when the lesion is peripherally located. It would appear from this study that the incidence of positive bronchial washings is sufficiently low that bronchoscopy undertaken for the sole purpose of obtaining washings is not indicated.

SUMMARY

1. Ninety-seven cases of proved bronchogenic carcinoma were bronchoscoped in a one-year period. Saline bronchial washings were obtained in all cases.

TABLE 2—TUMOR CELLS IN SPUTUM ACCORDING TO POSITION OF LESION

	Pos. Sputum	Neg. Sputum	Inadequate Samples*	Total
Visible Bronchoscopically	20	8	22	50
Not Visible Bronchoscopically	14	10	22	47
Total	34	18	44	97

*Indicates diagnosis established before three sputum specimens were obtained.

2. Positive sputum for tumor cells was less frequent when the lesion was not bronchoscopically visible indicating the need for more extensive sputum studies in these cases.
3. Where the neoplastic lesion was not visible bronchoscopically, the yield of positive cytological findings in the saline washings was less than ten per cent.
4. Bronchoscopy, merely for the purpose of obtaining bronchial washings, does not appear to be justifiable.

RESUMEN

1. Noventa y siete casos de carcinoma broncogénico demostrado se sujetaron a broncoscopía en un año. Se obtuvieron lavados salinos bronquiales en todos los casos.
2. Los resultados positivos para celdillas tumorales fueron menos frecuentes cuando la lesión no fue visible broncoscópicamente, lo que indica la necesidad de estudios de los esputos mas amplios en estos cases.
3. Cuando la lesión neoplásica no fue visible al broncoscopio el rendimiento de hallazgos positivos citologicos en los lavados salinos fue de menos de 10 por ciento.
4. La broncoscopía solo para obtener lavados bronquiales, no parece justificada.

RESUMÉ

1. 97 cas de cancers bronchiques avérés furent soumis à la bronchoscopie pendant une période d'un an. Des lavages salins des bronches furent pratiqués dans tous les cas.
2. Une expectoration donnant des cellules tumorales fut moins fréquente quand la lésion n'était pas visible bronchoscopiquement, indiquant la nécessité d'études plus complètes de l'expectoration dans ces cas.
3. Quand la lésion néoplasique n'était pas visible bronchoscopiquement, le produit des constatations cytologiques positives dans les lavages salins fut de moins de 10%.
4. La bronchoscopie ne semble pas justifiable si elle a pour seul but l'obtention de lavages bronchiques.

ZUSAMMENFASSUNG

1. Es wurden 97 Fällen von nachgewiesenem bronchogenen Carzinom im Verlauf von einem Jahr bronchoskopiert. Bronchialspülungen mit Kochsalzlösung wurden in allen Fällen vorgenommen.
2. Sputum mit positivem Befund auf Tumorzellen war weniger häufig, wenn die Veränderung bronchoskopisch nicht sichtbar war. Daraus ergab sich die Notwendigkeit für intensivere Sputumuntersuchungen dieser Fälle.
3. In den Fällen, in denen der neoplastische Herd bronchoskopisch nicht sichtbar war, betrug die Anzahl positiver cytologischer Befunde in den Kochsalzspülungen weniger als 10%.
4. Eine Bronchoskopie mit dem ausschliesslichen Zweck Bronchialspülungen machen zu können, scheint nicht gerechtfertigt.

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CARDIAC RUPTURE AND HEMOPERICARDIUM

The incidence of myocardial rupture while rare is by no means a pathologic curiosity. The incidence at Touro Infirmary for a ten-year period was almost 1 per cent of all necropsies and 6 per cent of all necropsied myocardial infarcts. The ratio of men to women in ruptured hearts is approximately one to one. Rupture is most apt to occur during the first week following infarction. In this series, 30 per cent occurred on the first day and 70 per cent occurred during the first week. No correlation between most drugs administered and rupture could be established except for anticoagulants and levarterenol which probably are associated with an increased incidence of rupture. Persistent hypertension and exertion are definitely more common in the ruptured group.

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The Natural History, Pathology and Treatment of Chronic Bronchitis*

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Because chronic bronchitis is the major respiratory problem in this country, I have decided to discuss its natural history, pathology and treatment. Nowhere else in the world does this one condition exact so heavy a toll in human suffering and economic loss to the community.

Chronic bronchitis is by no means a new entity. It was first described in 1808,[1] when it was observed to affect people between 60 and 70 years of age, who suffered from a winter cough, which lasted for a variable period.

Chronic bronchitis is now known as the "English Disease," and is the chief cause of loss of working time. Nearly 27 million days were lost in 1955-56, which is more than one-tenth of all the working days lost due to ill health.

Third in importance as a cause of death in England, the total mortality (29,760 in 1956) is 11 times greater than that of the United States. The death rate even varies in the different regions of England. That of Newcastle-on-Tyne, a heavily populated Northern industrial city, is much greater than that of Hampshire, a country area, free from industry and therefore, atmospheric pollution (Fig. 1).

The disease is found in 36 per cent of men over the age of 30, and is four times as common in men as in women. It is not common in class I and II of the English Registrar General's Social Classification (*i.e.*, professional classes and clerical workers), but there is an excess in Class V (unskilled workers).

There is no indication that any specific occupation in itself causes chronic bronchitis, but certain particular conditions, namely; unsatisfactory temperatures, drafts at work, and dust and fumes are associated with the disease. Moreover, the disease is more common in people performing heavy work.

Ogilvie[2] maintains that there is no association with dampness, although there is a higher incidence in those more densely occupied industrial riverside areas which are associated with atmospheric pollution, and "enclosed localities," *i.e.* houses surrounded by other buildings.

Clinicians define chronic bronchitis as a disease characterized by a long-standing cough with the production of sputum, in the absence of other causative disease. At this stage, the only physical signs are bilateral rhonchi and coarse crepitations.

It now appears that the factor of a chronic low grade atmospheric pollution is important in the pathogenesis of the disease. Death rates due to chronic bronchitis are 90 per 100,000 in highly industrialized cities, and 60 per 100,000 in rural areas.

There is a definite association between cigarette smoking and chronic bronchitis, the factor of having smoked cigarettes at all, for any length

*Third Prize, 1960 Essay Contest, American College of Chest Physicians.

of time, being relevant. Cigarette smokers nearly always have an excess of bronchial mucus, which may predispose to chronic bronchitis.[3]

One of the most important factors to be considered in the pathogenesis of chronic bronchitis is the relation of respiratory mucus to the disease. In health, the whole of the respiratory tract is covered with a thin layer of mucus, which is essential for the proper conditioning of the inspired air. Solid particles adhere to it, and noxious gases are largely dissolved before the air reaches the alveoli.

If there is excess mucus in the upper respiratory tract, the air-conditioning function of the nose is impaired, so that warming and moistening of the inspired air devolves on the bronchi, which are less well adapted than the nose for such a function. This may well affect the viscosity of the mucus, and if there is excess in the bronchi, the normal method of evacuation is overcome. Usually the cilia remove 150 mls. of mucus every day; if, however, this quantity is exceeded, and if the viscosity is increased, the cilia simply exert a churning action on the mucus, which then steadily accumulates. In the absence of acute infection, the cilia are usually intact, but if many mucus cells are discharging, the effective ciliary area may be reduced. Sulphur dioxide, in concentrations such as found in smoky towns, can inhibit ciliary action in the trachea.[4]

The respiratory mucus somehow lowers the resistance to infection by coating the bacteria and inhibiting phagocytosis and intraphagocytic

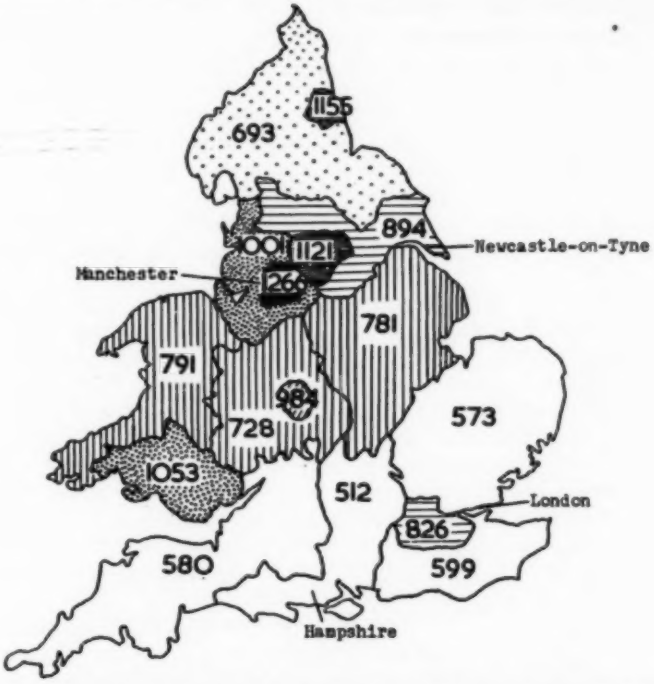

FIGURE 1: Bronchitis mortality in England and Wales; rates per million, 1950. (By courtesy of Professor D. D. Reid and the Honorary Editors of the *Proceedings of the Royal Society of Medicine*).

digestion by leucocytes, as well as preventing antibody uptake and its subsequent bactericidal action.[5]

There is a hereditary predisposition to chronic bronchitis; 10 per cent of Oswald's[6] patients had relatives suffering from the disease, but he believes that cross infection is unlikely. Whatever the predisposing causes, chronic and recurring respiratory infections are more common in bronchitics than in fit people, and appear to be the major precipitants of serious disability and death.[7]

The age of onset of symptoms can best be appreciated by observing Fig. 2.

Oswald found that the mode of onset of symptoms varied. Among 1000 cases, 524 were insidious in onset, whereas in 476, the symptoms started with an acute infection. Many of these latter patients considered that a single respiratory infection had converted them from healthy people to respiratory invalids. The mechanism of transition from acute to chronic bronchitis is still unknown. It is probable that following infection, the bronchi become hypersensitive to such nonspecific irritants as further infection, atmospheric pollution and cigarette smoke.

No one has as yet found an infective agent which can confidently be proposed as the precipitating cause of chronic bronchitis, but *H. influenzae* is an important etiologic factor, since its removal by antibiotics improves the illness. Additional confirmation of its role has been the demonstration of high antibody titers in the sera of those patients who regularly yielded this organism from their sputa.[8] Stuart Harris[9] considers that the pneumococcus can be found in the sputa of 50 per cent of bronchitics in the quiescent phase and during exacerbations.

It is still undecided whether these bacteria are the primary infectors of the respiratory mucosa. It may be that the influenza virus, by causing necrosis of the bronchial epithelium, promotes the entry of the bacteria. It is still uncertain whether the increased flow of mucus is a defense against infection or is a failure to limit infection. Any factor which increases the exudation of fluid into the lower respiratory tract is more likely to aid the bacteria than the host. The work of Olitski[5] would tend to support this view.

The morbid anatomy of chronic bronchitis cannot yet be presented as a complete picture which relates its beginnings and progressions to the causes which operate, for these factors are still largely unknown.

In early cases there is hypertrophy of the bronchial mucous glands, which is corroborated by excess mucus in the air passages and there is an increase in the number of goblet cells, so much so that they can be found in the bronchioles where they are normally scarce[10] (Fig. 3). Microscopically, the glands and the cells are distended with mucus. The ducts of the glands, which are tortuous and narrow, are liable to obstruction and may play a part in reinfection of the lung in cases of long standing chronic bronchitis; they may also maintain infection which would have otherwise subsided.[11]

In advanced cases, there is a superficial purulent bronchiolitis. The epithelium is often denuded and there may be a growth of fibrous tissue, suggesting early organization. Dilatation of the smaller bronchioles often occurs, and it may be diffuse or localized. The dilatation may occur beyond a constriction in a bronchiole which yet remains patent. Such a

narrowing may occasionally obliterate the bronchiole whose distal part is isolated as a cyst.

The alveolar changes are largely the result of disease in the bronchiole. There may be small pneumonic lesions, only a few millimeters in diameter, and there may be organization of the pneumonic exudate with subsequent contraction, or else ulceration of a pneumonic abscess into a bronchiole. There is usually intra-alveolar edema and there may be mucus lying free in the alveoli.

In some lungs there are many irregularly distributed nodules supplied by proximal bronchioles; half of these are pneumonic, one quarter show collapse, and the rest consist of fibrous tissue. These nodules, which are the remnants of a considerably larger volume of normal lung, represent localized changes of different ages in the lung periphery. Much of the acute change resolves and the dense fibrosis in some nodules suggests that scarring is not infrequent.

The bronchial and alveolar changes are not always parallel in severity, due to collateral circulation. Obstruction of a segmental bronchus may not cause collapse, as air can pass from lobule to lobule by drifting across the alveolar wall, and changes in the alveoli may be less than would be expected from the bronchial lesion.

Emphysema of the lungs is the result of long-standing chronic bronchitis, but no one is absolutely certain of its exact cause, although several factors are probably involved. Lynne Reid (1958) has defined

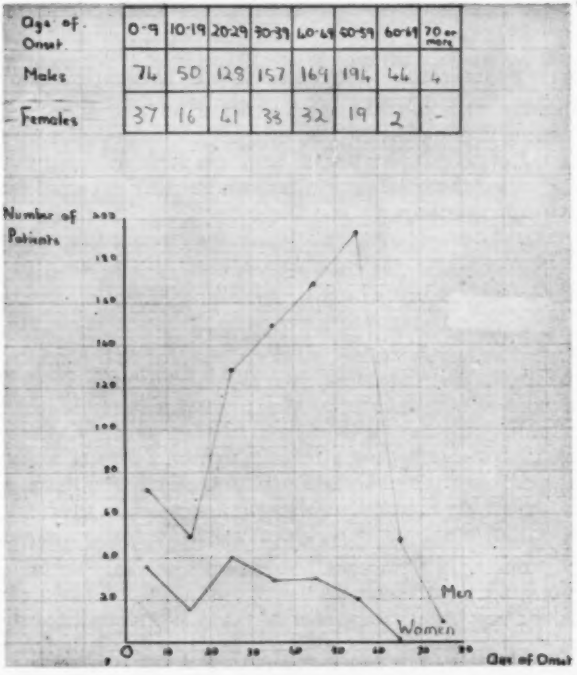

FIGURE 2: Graph constructed from Oswald's figures on the ages of onset of symptoms in 1,000 patients. (By courtesy of Dr. Oswald and the Editor of *Lancet*).

emphysema as an increase in the amount of air beyond the level of the terminal bronchioles. The main symptom in emphysema is dyspnea on exertion. There is a marked increase in the anteroposterior diameter of the chest, and the apex beat is difficult or impossible to palpate because the lungs are so bulky. The superficial area of cardiac dullness is absent, the lung fields are hyper-resonant, and the breath sounds are diminished with prolonged expiration.

In roentgenograms of advanced cases of emphysema, a narrow vertical heart with a prominent left border below the aortic knob can be seen, which is due to pulmonary artery dilatation and right ventricular hypertrophy. There is an abnormal pattern of small, prominent vessels in the hilar region, and these are widely spaced and reduced in number. The increase in air beyond the terminal bronchioles makes the lungs hypertranslucent.[12]

The functional residual volume is defined as the amount of air in the lungs at the end of normal expiration, and it is determined by a balance between the elastic forces of the lung and the passive forces of the chest wall. The basic defect in emphysema is a loss of the normal retractive force of the lung, and as a result there is an increase in the functional residual volume.

At necropsy, the lungs are pale, voluminous and dry, with bullae projecting onto the surface. The visceral pleura is thin, and there are dense pleural adhesions. On section, the lungs feel soft and pit on pressure due to loss of elasticity. Microscopically, the walls of the alveoli are thin, the septa between adjacent alveoli being reduced to small projections.

A check-valve mechanism as a cause of emphysema has been proposed. In emphysema, there is distension of every terminal air sac into a tiny tension cyst[13] due to the check-valve action of mucus which partially occludes the bronchi, so that air can be drawn in during inspiration, but is prevented from passing out during expiration. As we grow older, we develop atrophic emphysema, and in any lung undergoing this change there may be reflex arterial spasm causing areas of focal atrophy which eventually coalesce.[14]

Recently, Leopold and Gough[15] have described centrilobular emphysema which involves the central tissue of the lung lobule only and occurs in about 50 per cent of bronchitics. The enlarged centrilobular spaces are the distal orders of the respiratory bronchioles which rupture due to the bronchiolitis previously described (Fig. 4).

The main pulmonary arteries are dilated and atheromatous, while their branches may be narrowed. The proximal part acts as a reservoir, while the intrapulmonary narrowing points to an alteration in the rate of flow through the lung. There is destruction of the smaller arteries and the capillary bed arterioles due to endarteritis obliterans.

In emphysema, there is an inability to ventilate the blood due to a fault in the lungs. This impairment of hemorespiratory exchange is due to the formation of a dead space, consisting of air sacs not in contact with the pulmonary circulation.[16] In severe emphysema, perhaps all the inspired air enters this dead space, so that hemo-respiratory exchange would depend mainly on diffusion. In the later phases of the disease, a point is reached where there is hypoxia and hypercapnia due to a failure to maintain adequate alveolar ventilation.

Pulmonary heart disease, or cor pulmonale, is the main complication of severe chronic bronchitis and emphysema. It may be acute or chronic and is due to the combined effects of respiratory failure and changes in the pulmonary vascular bed. Fulton[17] (1953) found that 43 per cent of cases died due to congestive heart failure, 33 per cent due to acute lung infection, and the remainder died without acute respiratory infection and with minimal cardiac failure.

The right ventricular hypertrophy seen in long-standing chronic bronchitis and emphysema is due to pulmonary hypertension. It is a late development due to the constant efforts the organ must perform so as to pump blood into the lungs against the resistance of the reduced pulmonary vascular bed. The heart muscle itself is quite healthy.[18]

The abnormalities in the gases in the arterial blood may be direct precipitating factors in cor pulmonale. The development of heart failure causes an increase in hypoxia as the pulmonary edema so formed hinders the diffusion of oxygen across the alveolar membrane.[19] In moderate cases of emphysema, the arterial blood is 90 per cent saturated, in severe cases it is 78 per cent saturated, and in cor pulmonale it is 72 per cent saturated. The CO_2 pressure in the plasma ranges from 84-93 mm. of mercury. There is a compensatory increase in the bicarbonate reserve, without which there would be fatal acidosis due to inadequate alveolar ventilation.

Christie[16] considers that there is a compensatory polycythemia in advanced emphysema due to hypoxia, but Simpson[20] disagrees. He considers that polycythemia is infrequent, as severe hypoxia inhibits the bone marrow and the chronic pulmonary infection causes an anemia of infection. There are increases in the mean corpuscular volume and the packed cell volume, both of which are related to an increase in CO_2 tension.

Severe hypoxia can cause functional renal and hepatic failure, both of which are reversible if the hypoxia is relieved, and there may also be temporary psychologic changes.

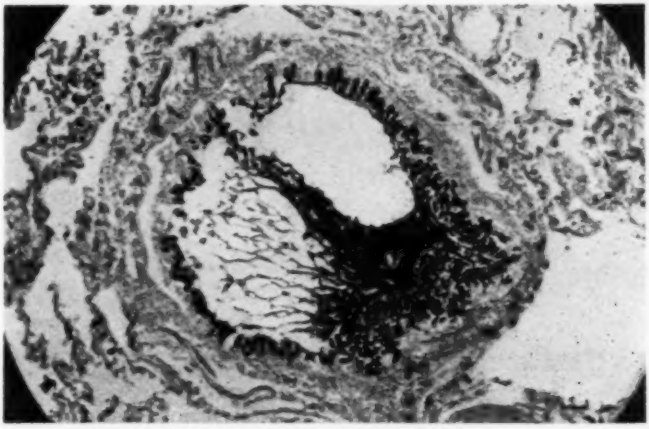

FIGURE 3: Hypertrophy of goblet cells. Mucus appears dark black on photograph. A similar section of a normal bronchiole would show only an occasional goblet cell. x 70. (Reproduced from Reid, L.: *Lancet*, 1:275, 1954).

Treatment

Deaths due to chronic bronchitis could be reduced considerably if atmospheric pollution were effectively controlled (Oswald, 1958) and cigarette smoking abolished.

Once the disease is established, the aim must be to prevent pathogens reaching the bronchioles and to overcome lobular inflammation as far as possible because this is responsible for the progressive nature of the disease. Patients should try to prevent contact infection and all infectious foci in the nose and throat should be treated efficiently. The antibiotic of choice is that one to which the pathogen is most sensitive.

Cases of cor pulmonale must be treated by those time-honored methods which are so successful. Bed rest is essential, and when there is pulmonary infection, it must be pursued relentlessly. Treatment with oxygen is accompanied by a lessening in cyanosis, but also by a further reduction in ventilation, and increased drowsiness due to the removal of the hypoxic stimulus from the respiratory mechanism. It is dangerous to give too large a quantity of oxygen for too long a period, and it should not be administered for more than 15 minutes every hour.

Discussion

Various factors operate at the onset of chronic bronchitis and once the bronchi are sensitized, any of the irritants may aggravate the symptoms. The disease is a failure of the defense mechanism of the lower respiratory tract to combat invasion by pathogens. Invasion by respiratory viruses to which we are all subject may be partly responsible for this.

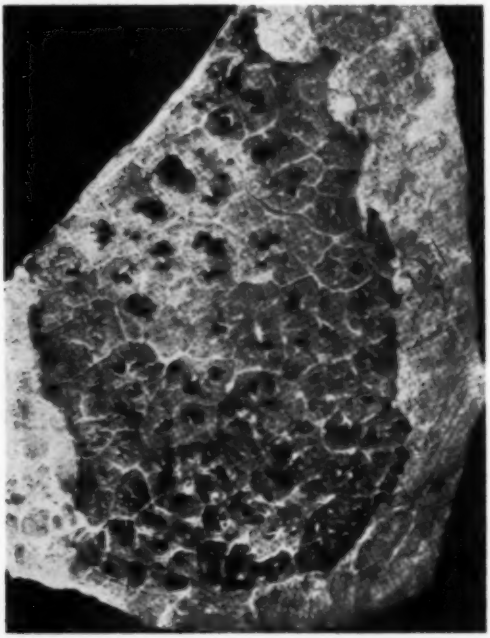

FIGURE 4: Cut surface of a lung showing interlobular septa and centrilobular emphysema. x ⅔. (Reproduced from paper by Leopold and Gough, 1957, by kind permission of Professor Gough and the editor of *Thorax*).

Disturbance of mucus secretion is the basic problem in chronic bronchitis, and it is suggested that the mucus is the result of external irritation, and causes the infection, rather than infection causing the production of the mucus.

In necropsy specimens, there is a gradation of change from acute inflammation to fibrosis. These manifestations of acute inflammation illustrate the changes which have occurred over many years; some may have been transient and have resolved uneventfully, whereas others have left a legacy of scarring. The extent of the changes and the speed at which they occur are the factors which influence the rate of development of symptoms.

The majority of acute exacerbations of chronic bronchitis and cases of cor pulmonale are seen in the winter months, but as soon as spring appears, the patient feels more fit and can face the world with hope.

The elastic recoil of the lungs is absent or diminished in emphysema due to the chronic hyper-expansion of the terminal air spaces. The factors causing pulmonary hypertension and right ventricular hypertrophy are considered.

Chronic bronchitis and emphysema are similar to cirrhosis of the liver and to progressive massive fibrosis of the lung. There is in all these conditions a point of no return where further progression is inevitable, and one can only slow down the unavoidable deterioration by suitable medical measures. Cure is not within the province of the medical profession. Only when the air we breathe is as clean as the water we drink will chronic bronchitis and emphysema disappear.

SUMMARY

1. Chronic bronchitis is the major cause of loss of working time and the third most important cause of death in England. It occurs in 36 per cent of men over age 30 and is four times as common in men as in women, being more common in the working classes.

2. Important in the pathogenesis are: atmospheric pollution and cigarette smoking, both of which lead to an excess of mucus.

3. There is an obliterative bronchiolitis together with a varying degree of superadded infection mostly due to *H. influenzae* and pneumococcus.

4. Pulmonary emphysema is the main complication of chronic bronchitis. The most important symptom is dyspnea of effort.

5. Cor pulmonale is the end result of emphysema and is due to respiratory failure together with changes in the pulmonary vascular bed. Right ventricular hypertrophy is always present due to pulmonary hypertension.

6. The main treatment of chronic bronchitis is the abolition of cigarette smoking and atmospheric pollution. In the well-established case, pathogens must be prevented from reaching the bronchioles by using appropriate antibiotics.

RESUMEN

1. La bronquitis crónica es la causa mas importante de pérdida de tiempo en el trabajo y es la tercera causa más importante de muerte en Inglaterra. Ocurre en 36 por ciento de los hombres de mas de 30 años y es cuatro veces más frecuente en hombres que en mujeres, siendo mas común en las clases trabajadoras.

2. Son de importancia en la patogenia: la polución atmosférica, y el fumar cigarrillos, ambas cosas productoras de esceso de moco.

3. Hay una bronquiolitis obliterante junto con un grado variable de infección sobreañadida de *H. influenzae* y neumococos.

4. El enfisema pulmonar es la complicación más importante de la bronquitis. El síntoma más importante es la disnea de esfuerzo.

5. El cor pulmonale es el fin del enfisema y se debe a la insuficiencia respiratoria asociada a los cambios en el lecho vascular pulmonar. La hipertrofia ventricular derecha está siempre presente debido a la hipertensión pulmonar.

6. El tratamiento principal de la bronquitis crónica es la abolición del cigarrillo y de la polución atmosférica. En el caso bien establecido se puede evitar la llegada de las substancias patogenas a los bronquiolos usando antibióticos adecuados.

RESUMÉ

1. La bronchite chronique est la cause majeure d'absentéisme et la troisième cause de décès en Angleterre. Elle survient chez 36% des hommes de plus de 30 ans, elle est quatre fois plus commune chez les hommes que chez les femmes, et plus répandue dans les classes ouvrières.

2. Sont importants dans la pathogénie: la pollution atmosphérique et la fumée de cigarette, l'une et l'autre amenant un excès de mucus.

3. Il y a une bronchiolite oblitérante, associée à un degré variable d'infection surajoutée due à *H. Influenza* et au pneumocoque.

4. L'emphysème pulmonaire est la principale complication de la bronchite chronique. Le symptôme principal est la dyspnée d'effort.

5. Le coeur pulmonaire est le résultat final de l'emphysème et est imputable à une insuffisance respiratoire associée à des altérations du lit vasculaire pulmonaire. L'hypertrophie du ventricule droit est toujours présente, imputable à l'hypertension pulmonaire.

6. Le traitement principal de la bronchite chronique est la cessation de la fumée de cigarette, et de la pollution atmosphérique. Dans les cas bien établis, on doit empêcher les agents pathogènes d'atteindre les bronchioles en utilisant les antibiotiques appropriés.

ZUSAMMENFASSUNG

1. Die chronische Bronchitis ist der Hauptgrund für den Verlust von Arbeitszeit und die dritte wichtigste. Todesursacher in England. Sie kommt in 36% aller Männer über 30 Jahre vor und ist viermal so häufig bei Maännern als bei Frauen; ferner tritt sie häufiger bei der arbeitenden Bevolkerungsgruppe auf.

2. Von Bedeutung für die Pathogenese sind: atmosphärische Verunreinigungen und Zigarettenrauchen; beide führen zu einem Übermaß an Schleim.

3. Es liegt eine obliterative Bronchiolotis vor zusammen mit verschiedenen Graden von Superinfektion infolge *H. influenza* und pneumococcus.

4. Ein Lungenemphysem ist die hauptsächlichste Komplikation der chronischen Bronchitis. Das Hauptsymptom ist Kurzatmigkeit bei Anstrengung.

5. Cor pulmonale ist das Endresultat des Emphysems und ist die Folge der respiratorischen Insuffizienz zusammen mit Veränderungen im pulmonalen Gefäßbett. Immer liegt eine Hypertrophie des rechten Ventrikels vor als Folge des pulmonalen Hochdrucks.

6. Die Hauptbehandlung der chronischen Bronchitis besteht in der Beseitigung des Zigarettenrauches und der atmosphärischen Verunreinigung. Bei stark ausgeprägten Fällen müssen die pathogenen Keime durch Anwendung entsprechender Antibiotika daran gehindert werden bis zu den Bronchiolen vorzudringen.

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Spontaneous Hemopneumothorax

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A massive hemothorax occurring concomitantly with spontaneous pneumothorax may reach catastrophic proportions. Realistically, the continued propulsion of blood into the pleural space subsequent to a spontaneous pneumothorax must be approached in the same diligent manner as hemothorax resulting from external trauma.

Although hemopneumothorax due to spontaneous rupture of the lung substance is not a common occurrence and available literature is not extensive, recognition of this disease entity dates back to 1828. Two case reports published independently in 1901 described fatal results in each instance. In more recent years several cases of severe or massive hemorrhage associated with spontaneous pneumothorax have been reported. Approximately 20 to 25 per cent of the reported cases have been fatal, however, this figure is unduly pessimistic and not in keeping with the present medical facilities and surgical management.

Discussion

Spontaneous pneumothorax is a disease seen in young people between the ages of 20 and 40, but predominantly in men. One side of the chest is as frequently involved as the other. Although there is some controversy as to what percentage of bleeding occurs in all cases of spontaneous pneumothorax, the frequency is sufficient to stress awareness of this condition.

Diagnosis

Clinical evidence of pneumothorax is usually obvious. Symptoms may vary from a sharp chest pain of a sudden nature to gradual and rather vague discomfort. This initial phase may exist over a period of a few hours or longer. Pain may appear in the chest, upper abdomen or neck and shoulder region. The occurrence of an associated hemothorax should be considered when the patient experiences increasing dyspnea, a state of shock and marked shift of the mediastinum. The occurrence of the hemorrhage may be ascertainable at the time of the first examination; however, it is not unusual for the hemorrhage to be delayed from a few up to 48 hours.[1] The cause of the bleeding is in all probability the result of fracturing of vascular adhesions as they exist between the visceral and parietal pleura; and when the lung collapse occurs, there is a tearing with subsequent outpouring of blood into the pleural space. Even though this may be a relatively small vascular leak, nevertheless, it is capable of promoting a rather sizable accumulation of blood in the pleural space as there is relatively no opposition exerted to promote its closure.[2] The bleeding is secondary to a torn intercostal vessel or other systemic vessels.

Treatment

Clinically, the acuteness of onset will vary with the rate of accumulation of air and blood in the pleural space.[2] Therefore, one must decide whether the patient may be treated with aspiration and other supportive measures or as an emergency case for thoracotomy. When active bleeding is present, bedrest, sedation, transfusions as indicated, and aspiration

of the blood and air from the chest are essential measures to be instituted immediately. If the patient responds to such therapy by improvement in his vital signs, expansion of the lung and cessation or slowing of the bleeding occurs; then, further conservative measures are sufficient. Serial x-ray films of the chest and constant alertness on the part of the surgeon directed toward changes in lung expansion or further bleeding will aid in determining the appropriate plan of action. Restoration of complete expansion of the involved lung and unimpaired function is the goal of treatment. When shock, dyspnea, blood loss and mediastinal shift are progressive in spite of supportive therapies, including transfusions, then thoracotomy is imperative. It should be emphasized that this approach is not advocated for cases of spontaneous hemopneumothorax in which there is no evidence of a deteriorating status of the patient, and relatively little, if any, evidence of persisting bleeding after the initial episode. Cases of this type may be controlled by multiple aspirations as necessary, to facilitate expansion of the lung and removal of the accumulated blood unless the leak in the lung surface is of sufficient size to allow reaccumulation of air and the possible development of tension pneumothorax. In such instances, it is advisable to introduce intercostal tubes, one at the apex anteriorly for the evacuation of air and the other at the base of the pleural space for the removal of blood. The use of intercostal tubes for a patient who is bleeding actively and whose condition is progressively becoming worse, is to be avoided other than when the utilization of such measures for decompressive purposes are necessary, prior to thoracotomy. If surgical and hospital facilities are available for definitive treatment by thoracotomy, then intercostal catheter insertion is not advantageous.

A standard posterolateral thoracotomy incision is used to open the chest. Evacuation of blood from the pleural space and control of the hemorrhage by ligation of the bleeding vessel is then accomplished. In a large number of cases one finds pleural blebs and bullae especially in the apical region and frequently, it is possible to identify the particular leak which has been responsible for the occurrence of the pneumothorax.[4] After the lung is freed from the attachments to the parietal pleura, wedge resections and segmental resections or subsegmental resections when indicated, are the procedures of choice. If several fairly large blebs are present over the surface, it is wise to incise these blebs and then to suture across with silk to prevent recurrences. The entire surface of the lung and the parietal pleura are then mechanically abraded with gauze.[5] In order to realize complete expansion, two thoracotomy tubes are introduced into the pleural space and connected to underwater drainage bottles and to suction.

Case Reports

Case 1: This 32-year-old white man experienced severe chest pain on the left side while eating breakfast. Difficulty in breathing was almost immediate. The pain extended to the left shoulder region. He was admitted to his local hospital on August 17, 1955, and was transferred to Central Baptist Hospital in Lexington, Kentucky, on the same date. He had a history of pneumothorax in 1951 involving the same side. Definitive treatment at the local hospital had consisted of thoracenteses with the removal of air and about 1500 cc. of blood.

He was experiencing increasing difficulty in breathing as well as continual chest pain. Due to the failure to respond to supportive therapy, thoracotomy was performed.

On entering the pleural cavity, 1800 cc. of liquid blood and clot formation were aspirated. There was no further significant bleeding following the evacuation of the blood. However, in the apex just over the route of the subclavian vessel, the pleura had been torn and a small branch of an intercostal vessel was continuing to ooze. Control was by suture fixation. Expansion of the lung allowed examination of its surface and the disease was limited to the peripheral part of the apical segment of the upper lobe. This area was emphysematous and contained several small blebs. Following wedge resection of the diseased part, mechanical pleurodesis was performed on all surfaces and two chest tubes inserted for drainage. The postoperative course was satisfactory and he was discharged on the ninth postoperative day. The pathologic diagnosis was pulmonary emphysema.

Case 2: This 30-year-old white man was admitted to the Central Baptist Hospital on October 27, 1957. A diagnosis of intrathoracic bleeding had been established by the referring physicians and was presumed to be secondary to spontaneous pneumothorax and rupture of a blood vessel. He had been essentially well on the day prior to admission. However, in the latter part of that particular day, he experienced mild chest pain on the right with dyspnea which became severe over the course of a few hours. His condition began to deteriorate over a 12 hour period; it was necessary to administer eight pints of blood at his local hospital and another was given en route to the Central Baptist Hospital. Thoracenteses and introduction of two thoracotomy tubes into the right pleural space were performed by the local physicians for the evacuation of the rapidly accumulating blood deposit. These were also necessary for decompression of the pressure being exerted against the mediastinum by the massive accumulation of blood. His past history referable to the chest was non-contributory. Physical examination revealed a white man in a severe state of shock. Blood pressure was

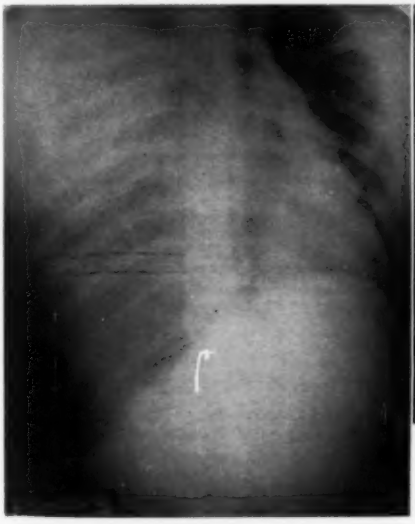

FIGURE 1

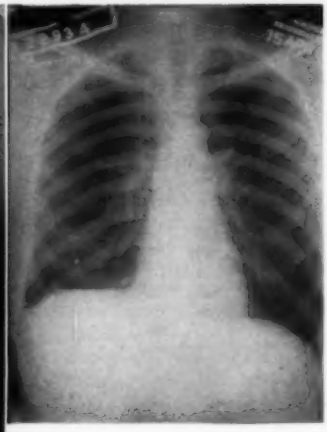

FIGURE 2

FIGURE 1: The admission chest x-ray film reveals the opacity throughout the entire right hemithorax. The diaphragm is markedly depressed and the mediastinum severely shifted to the left. FIGURE 2: Postoperative chest x-ray film dated April 1960.

80/60. Pulse was 120 and weak. Breath sounds were completely absent on the right side and there was a marked shift of the mediastinum to the left. Breath sounds were audible throughout the left chest other than medially, due to the mediastinal shift. There was dullness throughout the entire right lung field. The heart sounds were distant. Due to his rapidly deteriorating status, as reflected by continued bleeding and failure of supportive measures to overcome the state of shock, it was imperative that operative intervention be initiated. A right posterolateral thoracotomy incision was made and a large quantity of free blood and multiple clots were evident in the pleural space. The free blood was estimated at 2,000 cc. exclusive of the clot formation. Following the evacuation of this blood, the right lung was expanded and within a few minutes following the administration of additicnal blood, his blood pressure responded by returning to a normal level. Examination of the lung at that time

revealed the presence of several grape-like blebs at the apex of the upper lobe. It was at this point that a small fibrous band which had pulled loose from the apex of the pleural space was evident; therefore, the point of bleeding was at the apex of the pleural space and not from the lung itself. Multiple fixation sutures were placed about the point of bleeding and this constant leak was thereby controlled. A subsegment of the apical segment was excised to remove the existing emphysematous blebs. He rapidly improved over the course of the next 24 hours. The subsequent period of hospitalization was uncomplicated. Follow-up studies have revealed a continued satisfactory condition referable to the respiratory system.

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SYNDROME OF INTRAPULMONARY SEQUESTRATION

Pathogenesis, pathology and clinical manifestations with a special emphasis on radiologic appearance, of the syndrome of congenital pulmonary cysts and anomalous artery are described, and the pertinent literature reviewed. Two new cases are reported: Case 1 female, age 28, followed from 1954 to 1959. The lesions in the right lower lobe were diagnosed initially as tuberculosis and later as a pulmonary arteriovenous aneurysm communicating with the aorta. In the resected specimen, multicavitary cyst was found without communication with the bronchial tree, and additional artery coming from the supradiaphragmatic portion of the aorta. Case 2: male, age 32, for ten years had productive cough, expectoration mostly purulent; congenital pulmonary cyst, infected, was diagnosed. In the excised left lower lobe the following anomalies were found: (1) multicavitary cyst communicating freely with the normal bronchial tree; (2) anomalous artery branching from infradiaphragmatic portion of the aorta; (3) absence of pulmonary vessels in the left lower lobe. It is concluded that in cases of pulmonary cyst localized at the base of the lung selected aortography should be done.

Dybicki, J., Borowska-Lehman, J., and Jungowska, A.: "The Syndrome of Intrapulmonary Sequestration." *Gruzlica*, 29:431, 1961.

RECURRENT SPONTANEOUS PNEUMOTHORAX

Fifty-six patients who had recurrent spontaneous pneumothorax were observed. Seven were treated with closed tube thoracotomy with talc poudrage by insufflation. The remaining 49 patients underwent a total of 52 open thoracotomies, 3 patients having bilateral stage procedures. The usual finding consisted of apical blebs (45 instances). The definitive treatment generally consisted of wedge resection of the blebs combined with pleural scarification. Followup in 78 per cent of the patients revealed a single isolated recurrence in a patient who was inadequately treated by present standards.

Driscoll, P. J., and Aronstam, E. M.: "Experiences in the Management of Recurrent Spontaneous Pneumothorax," *J. Thor. and Cardiov. Surg.*, 42:174, 1961.

Idiopathic Disseminated Pulmonary Ossification*

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Disseminated ossification of the lungs is rare. Most of the cases reported in the literature are associated with mitral stenosis, hemosiderosis and granulomas. Wells and Dunlap,[1] in a review of the literature in 1943, stated that about 45 cases of diffuse ossification of the lung unassociated with tuberculous scars had been reported, of which about 35 cases were of the racemose or branching type. Most of these cases were found in the German literature. A review of the English literature since the article by Wells and Dunlap fails to reveal a single case of disseminated pulmonary ossification of the idiopathic type, that is, pulmonary ossification not associated with mitral stenosis or hemosiderosis.

Even the rarity of disseminated pulmonary ossification associated with mitral stenosis is stressed by several authors.[2-5] Lawson[3] in England in 1949 was able to collect 40 cases. Wilson, Sasaki and Johnson[5] in 1959 were able to find only 23 cases adequately documented by necropsy or lung biopsy. They stated that other cases have been reported on the basis of radiologic examination, but lacked pathologic confirmation. They found only three confirmed cases in the American literature; to this they added four, all associated with mitral stenosis. The case herein reported is one of disseminated ossification of the lungs of the idiopathic type, not associated with mitral stenosis or hemosiderosis.

Report of Case: The patient, a 73 year-old Caucasian man, was admitted to the Harbor General Hospital on three separate occasions, starting in August, 1948. At this time, he had a urethral stricture associated with scrotal cellulitis and perineal fistulae. Dilatation of the urethra and supportive measures were instituted. He was readmitted in November, 1948, when fistulectomy, bilateral orchiectomy and scrotectomy were performed. In August, 1952, he was readmitted for the third and last time with the complaints of urinary bleeding, back pain, abdominal pain, chills and fever.

He fractured his right fifth, sixth and seventh ribs about 15 years ago; surgery consisted of closure of chest wound. He stated that he had had gonorrhea about 45 years ago. The family history was essentially negative.

The physical examination revealed a well developed and well nourished white man in no acute distress. His temperature was 99°F., pulse 100, respirations 24, and blood pressure 140/80. The thorax was increased in postero-anterior diameter. A scar involved the right chest wall. The lungs were clear. The heart sounds were faint and the rhythm regular. A-2 was greater than P-2. No murmur or thrill was evident. The abdomen was obese and nontender. There was a right direct inguinal hernia and a lower midline cystostomy scar. The testicles and scrotum had been surgically removed. Rectal examination was negative. The lower extremities revealed small varicosities and one plus pitting edema.

The urine was grossly bloody, had a specific gravity of 1.020 and 3+ albumin; microscopic examination showed numerous red blood and white blood cells. A urine culture showed gamma streptococci and coagulase negative *Staphylococcus albus*.

Hematologic examination revealed hemoglobin 9.5 gm., red blood cells 3,490,000, white blood cells 9,200 with a differential percentage of 18 bands, 40 neutrophils, 36 lymphocytes and six mononuclear cells. The platelets were adequate.

A chest x-ray film on September 2, 1952 revealed callus formation of the fifth, sixth and seventh ribs, in posterior axillary line. Pleural thickening was present in the right base. The left base and sulcus were clear. There was no evidence of infiltration in either lung. The cardiac silhouette was negative.

Cystoscopy revealed a bladder tumor involving the left wall which on biopsy showed an invasive squamous cell carcinoma. On October 7, 1952, a large intravesical tumor of the posterior floor, lateral wall and vault was resected. His postoperative condition was poor; he went into shock and was treated symptomatically. He developed pulmonary edema and expired on October 25, 1952.

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The necropsy revealed a recent transverse suprapubic abdominal incision 5 cm. in length, slightly open, which exuded a small amount of turbid fluid. A small fistula extended from the urinary bladder to the suprapubic abdominal wall. The bladder was adherent to the abdominal wall; the pericystic tissue was hemorrhagic. The urinary bladder contained purulent material and the mucosa of the posterior wall was ulcerated. Microscopically, the bladder wall was invaded by an undifferentiated squamous cell carcinoma. The ureteral orifices were patent. The prostate gland was moderately nodular.

The kidneys were mildly enlarged, each weighing 170 gm. and the capsules stripped with relative ease revealing grayish-tan surfaces from which projected numerous abscesses measuring up to 2 cm. in diameter; some pus was present in the perinephric fat. Microscopically, there were areas of acute pyelonephritis with abscesses and moderate arteriosclerosis. The pelvis and ureters contained cloudy fluid, but were free from other abnormalities.

The heart weighed 360 gm. There was a moderate amount of subepicardial fat. The chambers were patent and the right and left ventricular walls measured 0.3 and 1.2 cm., respectively. The bases of the mitral and aortic valves showed mild sclerotic thickenings. The valves, which had the following measurements, tricuspid 13, pulmonic 9, mitral 12 and aortic 9 cm. in circumference, showed no evidence of rheumatic fever. The coronary arteries were patent and showed mild sclerotic changes. Microscopically, the myocardium of the left ventricle revealed several small areas of fibrosis. There was moderate sclerosis of the abdominal aorta.

The liver weighed 1550 gm. and several capsular fibrous tags were adherent to the diaphragm. The cut sections revealed passive congestion. In addition, on microscopic examination, small foci of polymorphonuclear leucocytes were present in midzonal areas. The gallbladder was moderately distended with bile and contained several stones of the mixed variety. The bile ducts were patent.

The spleen weighed 400 gm. and was adherent by fibrous bands to the diaphragm and stomach. There was a subcapsular abscess measuring 2.5 cm. in diameter; the remainder of the spleen showed an acute splenitis.

Except for dilatation and congestion of the ileum, the gastrointestinal tract revealed no abnormality.

The pancreas revealed a few focal areas of acute inflammation and fat necrosis. There was moderate lipid depletion of the adrenal glands.

The Lungs: The right thorax revealed an old scar extending from the sixth intercostal space in the anterior axiliary line to the eighth intercostal space in the posterior axillary line, a distance of 6 cm. There were old adhesions involving the visceral and parietal pleura of the lower lobe of the right lung; a few old adhesions involved both apices. In both lower lobes and in the left upper lobe, there were numerous scattered subpleural bone spicules, measuring up to 0.5 cm. in length; most of the spicules measured 0.2 to 0.3 cm. These spicules were incorporated, in many instances, within the lung parenchyma, for a distance of 3 to 4 cm. from the pleura and several involved the interlobar septae. Uninvolved lung parenchyma separated spicules of bone. Many of the bone fragments had sharp ends and shelled out easily. No bone was found in

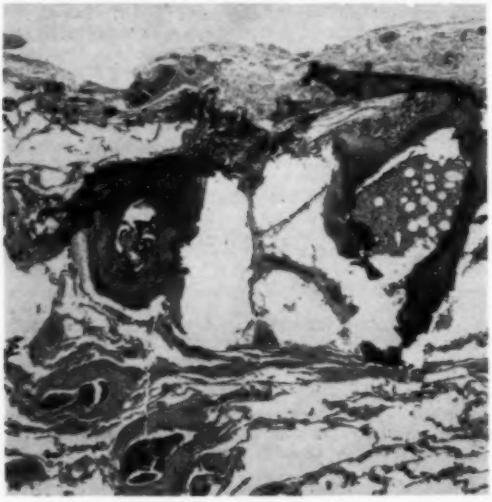

FIGURE 1: Bone spicules in subpleural alveoli. (H. and E. X60)

the adhesions of the apices. The lungs otherwise showed moderate emphysema of all lobes, with small scattered areas of bronchopneumonia. The lower lobes were congested.

Microscopically, there were many scattered spicules of bone underlying and within the moderately thickened visceral pleura, and occupying distended alveolar spaces (Fig. 1). The alveolar septae were thin-walled or moderately thickened and frequently ruptured. The spicules contained islands of hemopoietic marrow (Figs. 2 and 3). These islands were extremely cellular and had occasional magakaryocytes. Nowhere were there islands of undifferentiated mesenchyme, nests of granulation tissue and hemosiderocytes upon which bone may be formed, or immature bone of the woven type. In essence, the bone was of the mature type without evidence of immature bone formation.

Discussion

Disseminated ossification of the lungs is classified into two forms: (1) nodular circumscribed and (2) racemose or branching, or trabecular. These are differentiated anatomically and in the kind of patients involved.

The nodular circumscribed form chiefly affects young people with mitral stenosis. Most of the cases observed have been in men under the age of 40,[5] with an occasional patient between 40 and 50.[1] These patients had advanced cardiac disease, almost exclusively mitral stenosis, with accompanying congestive failure. Radiologic examination showed the characteristic findings of mitral stenosis and many discrete opacities throughout the lung fields, but mainly involving the lower lobes, especially the right. The bony nodules at necropsy were discrete, widely scattered throughout the lungs, usually subpleural, and in the form of small, flat or oval plaques measuring from 2 to 8 mm. These nodules appear to be the result of connective tissue proliferation, following the organization of chronic pulmonary passive congestion or interstitial pneumonitis, producing a bony metaplasia.

The branching or trabecular form, on the other hand, almost invariably involves men of advanced years. Daust[6] found the average age of patients having this form to be 67 years. Approximately 30 per cent of the cases collected by Daust (7 of 23 patients) had cardiac disease of the arteriosclerotic type; none had evidence of mitral stenosis. The bone lesions have been described as consisting of branching spicules of true bone, deposited in the septums of the lungs, often continuous for some distance but with isolated spicules. The process is usually more localized than the nodular circumscribed form. The bone spicules are considered to result from metaplasia of senile alterations of perivascular connective tissue. Osteoid tissue is laid down in the vascularized connective tissue and is then converted to true bone. Marrow formation is occasionally observed, but not nearly so frequently as that found in bone resulting from calcification of tuberculous scars or ossified bronchial cartilage.

In the case herein reported, the patient was an elderly man who had evidence of mild arteriosclerotic heart disease, involving mainly the base of the mitral and aortic valves, but without evidence of rheumatic endocarditis. Cardiac failure was of a mild degree, as revealed by passive congestion of the lower lobes of the lungs. The patient, furthermore, had not succumbed to cardiac failure, but to a septicemia, resulting from an ascending pyelonephritis, following a partial resection of an invasive squamous cell carcinoma of the urinary bladder.

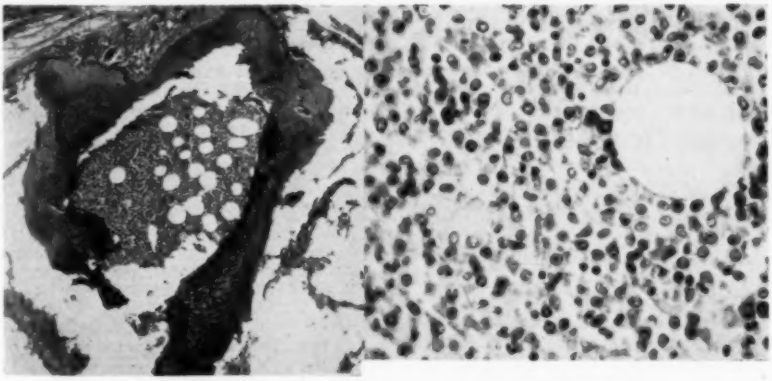

FIGURE 2 FIGURE 3

FIGURE 2: Mature bone spicule with marrow within alveoli. (H. and E. X90). FIGURE 3: Bone marrow of spicule of Figure 2. (H. and E. X500).

The old trauma of the right thorax had produced scar tissue and pleural adhesions of the lower lobe of the right lung. Bone, however, had not occurred in these tissues and it was more pronounced in the opposite lung.

The characteristic bone lesions were laid down in subpleural fibrous tissue and in intra-alveolar spaces; an occasional bronchial cartilage plate was ossified. The bone was in the form of mature trabeculae, having cement lines, osteocytes and ill defined osteoblasts. Most of the spicules had well defined marrow with myeloid and erythroid elements and occasional megakaryocytes. The bone being of small size, mainly under 5 mm. in length, was not visible roentgenologically. Nowhere was immature woven bone seen. The bone, hence, gave the impression of having been present of long duration.

The pathogenesis of idiopathic pulmonary ossification, and for that matter, of pulmonary ossification associated with mitral stenosis, is obscure. It is known that mesenchymal tissue, rich in proliferative connective tissue and blood vessels, is the framework upon which bone is formed.[7] This tissue may form in areas of organizing chronic passive congestion, and of pneumonitis. Calcified woven bone appears first, and upon this structure, bone is built and replaced by the maturer lamellar bone. Later myeloid conversion occurs, once maturity and stability of the bone is achieved. Hence, the maturity of the bone formed may depend on the duration of the development of the bone. In those patients who die from mitral stenosis, younger bone forms are usually seen, since the bone may have insufficient time to become mature.

Other factors, however, besides chronic passive congestion and its framework of mesenchymal tissue, must be present before bone develops in the lung, since bone is uncommon in cardiac failure, even of long standing. Grishman and Kane,[2] in discussing the origin of bony nodules associated with mitral stenosis, state that since the lesions were already established before any clinical congestive failure appeared, the precursor to these lesions must appear early in rheumatic fever and probably in childhood. Factors other than, or in addition to, vascular congestion must be involved even though the distribution of the nodules at the bases favor congestive failure and their sequelae. Such factors, however, are unknown.

It is possible that some pulmonary bone spicules may result from the development of intrapulmonary embryonic mesenchymal rests. In the development of the lungs in the embryo, as the lungs invade the spongy mesenchyme of the body wall, and are surrounded by the developing ribs, it is possible that some mesenchyme or rib *anlage* may become encompassed in the developing lungs. This tissue may then remain as embryonic remnants and under proper stimuli, subsequently develop into rudimentary ribs or bone trabeculae. In this way, then, some cases of pulmonary ossification, in which pulmonary congestion and pneumonitis are of a minor degree and of short duration, could be explained.

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PAPILLIFEROUS TUMORS OF THE HEART VALVES

Two papilliferous tumors of the semilunar valves are described. One occurred on the pulmonary valve of a man aged 57 years and gave rise to no symptoms. The other grew on the anterior cusp of the aortic valve of a woman aged 45 years. This partially filled the anterior aortic sinus close to the ostium of the right coronary artery and was associated with angina pectoris during life.

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Chronic Pneumonitis of the Cholesterol Type

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This paper presents a case of fibrosing lung disease of the cholesterol type that was diagnosed by lung biopsy and treated with corticosteroids. The patient had several interesting responses to treatment both symptomatically and somatically.

Postmortem examination revealed his disease to be rather widespread; therefore, this case falls into the category of a fibrosing pneumonitis with generalized granulomatous angiitis.

Case Report: S. K., a 36 year-old Austrian stone driller, entered the Allentown Hospital on June 22, 1955 with a history of progressive cough of four months and weight loss of 40 pounds. The cough was mucous-producing without hemoptysis. Anorexia, fever, chills, and nightly sweats were other complaints. Tightness across the chest and occasional dull, intermittent pain in the right lower chest, not definitely related to breathing, were noted. His past medical history was negative. There was no history of allergy, treatment with sulfonamides, oily nosedrops or mineral oil. His system review and family history were unremarkable. His social history was remarkable only in that he had worked in a stone quarry for the last nine years. He smoked 15 to 20 cigarettes per day. He had no exposure to tuberculosis or psittacine birds.

The physical examination revealed a pale, asthenic, febrile, 130 pound white man showing obvious weight loss with clubbing of fingers and toes. The chest showed an increase in antero-posterior diameter, limited diaphragmatic excursions, and hyperresonance to percussion. The lung fields had bilateral moist, crackling, inspiratory rales at the bases and in the left upper lobe posteriorly.

Laboratory studies, including complete blood count, fasting blood sugar, serology, serum proteins and electrolytes, were completely normal. Cholesterols ranged from 270 to 300 mg. with 70 to 75 per cent esterification. The sedimentation rate was 104 mm./hr. The purified protein derivative first strength was negative; the second strength was positive. Twenty sputum cultures and several gastric washings for acid-fast bacteria were negative. The ECG was suggestive of some right ventricular enlargement. The chest x-ray film revealed nodular hilar densities with increased diffuse parenchymal markings compatible with bilateral pneumonoconiosis or fibrosis. Bronchoscopy on June 30 showed chronic bronchitis. Bronchial aspiration smears and cultures were negative for acid-fast bacteria and malignant cells. Spinal fluid examination, blood cultures, malarial smears, and sternal marrow showed no abnormality. Cultures and agglutination tests for granulomatous and fungus diseases done by the Department of Health were all negative. Muscle and liver biopsies were normal.

The patient continued to have a septic temperature with spiking in the afternoon to 104.6°F. by rectum. His hemoglobin dropped to 10.4 gm. No source of blood loss was found. The sedimentation rate remained above 100 mm./hr. The clubbing of his fingers and toes and the beaking of the nails progressed and he complained of malaise and fatigue.

No therapy, including antibiotics and tuberculostatics, seemed to affect the disease or change the fever pattern. Therefore, they were discontinued. The temperature spontaneously decreased to normal.

Tissue obtained by thoracotomy from the left lower lobe of the lung on August 12 cultured no acid-fast bacteria or fungi. Microscopic examination of the lung tissue revealed thickening of the pleura with considerable hyalinization and prominent, dilated vascular channels. The parenchyma adjacent to the pleura showed granulomata with numerous multinucleated giant cells, not of the Langhans' type, and large mononuclear cells protruding into the alveolar lumina. Many of the giant cells contained slit-like spaces consistent with cholesterol clefts. Adjoining areas had increased fibrous tissue with marked hyalinization of the collagen. No caseation was observed. Fibrous areas were infiltrated by mononuclear cells, lymphocytes, and plasma cells. The findings were compatible with chronic pneumonitis of the cholesterol type.

TREATMENT WITH STEROIDS

In view of the diffuse involvement of the lungs, surgery was precluded and medical treatment with prednisolone† was started on September 4. After two 5-mg. tablets, he became acutely short of breath and the medication was discontinued.

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†Sterane by courtesy of Pfizer Co.

On September 6, we resumed with 2.5 mg. of prednisolone every six hours, but 30 minutes after the third dose (7.5 mg.) he developed shortness of breath, some cyanosis, and temperature of 102.4°F. by rectum. Expiratory wheezes were heard over both lung fields.

These prednisolone tablets contained magnesium trisilicate, dicalcium phosphate, magnesium sterate, lactose and potato starch. We were unable to find allergy to those substances on patch testing or ingestion.

On September 24, desensitization was attempted with 0.5 mg. of steroid every hour, totalling 3 mg. daily, which was well tolerated. The dose was slowly increased to 15 mg. daily over a month's period; however, respiratory symptoms again appeared when a single dose reached 5 mg. He was maintained on 10 mg. daily without untoward effect. He seemed improved and gained seven pounds. His vital capacity increased from 1.1 liter to 1.9 liter. Very remarkable was the decrease in his pulmonary osteoarthropathy which almost vanished. However, chest x-ray films and repeated clinical findings remained unchanged.

An intermittent course with intramuscular ACTH, after slow reduction of prednisolone, was not tolerated.

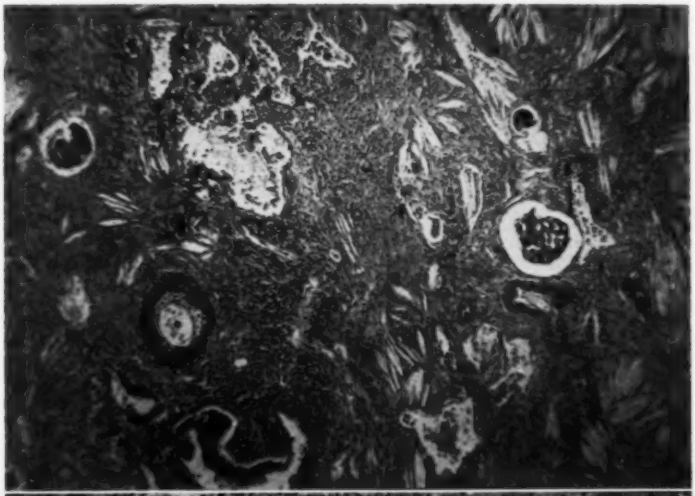

FIGURE 1

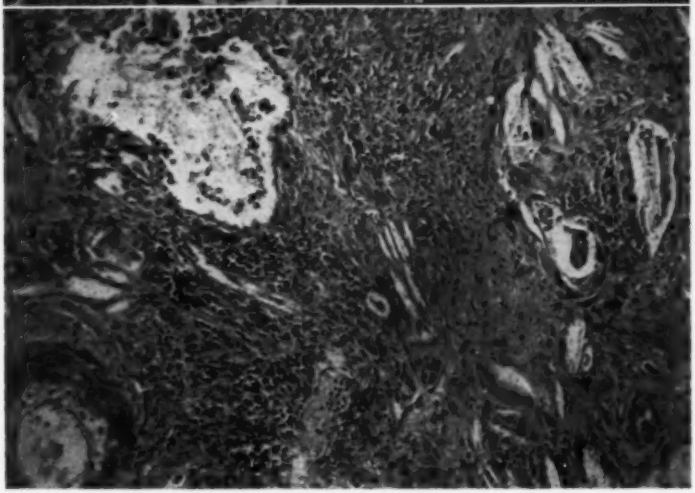

FIGURE 2

FIGURE 1: Lung tissue showing granulomatous lesions and many cholesterol clefts.
FIGURE 2: Lung tissue showing in detail endothelial proliferation, lymphocytic infiltration, fibrosis and cholesterol clefts.

Prednisolone was discontinued on February 6 after 135 days of therapy, the dose having been decreased slowly and gradually over a two months' period. He was now able to leave the hospital for short walks and his vital capacity increased to 2.6 liters.

He showed signs of right-sided heart failure on March 26 and was digitalized. In spite of symptomatic therapy (including oxygen by intermittent positive pressure and blood transfusions) he lost 14 pounds of weight and weakness and dyspnea increased. Several courses of steroid therapy seemed to delay his clinical deterioration. X-ray films showed marked progression of the fibrosis. He expired 577 days after admission.

At autopsy, the right lung weighed 1150 and the left, 1050 gm. Diffuse fibrosis of the parenchyma and pleura was the predominant finding. No nodularity could be demonstrated. Cavities or caseation were absent. Peripheral emphysematous blebs and parenchymal edema were present. The bronchi had changes consistent with chronic bronchitis. The heart weighed 560 gm. with right-sided hypertrophy and dilatation. The liver weight was 2050 and that of the spleen 700 gm. with marked congestion of both organs and early fibrotic changes. The adrenal cortices measured less than 0.2 cm. in thickness. The aorta showed atheromata without ulceration in its abdominal part and the preaortic lymph nodes were enlarged. All other organs were grossly not remarkable.

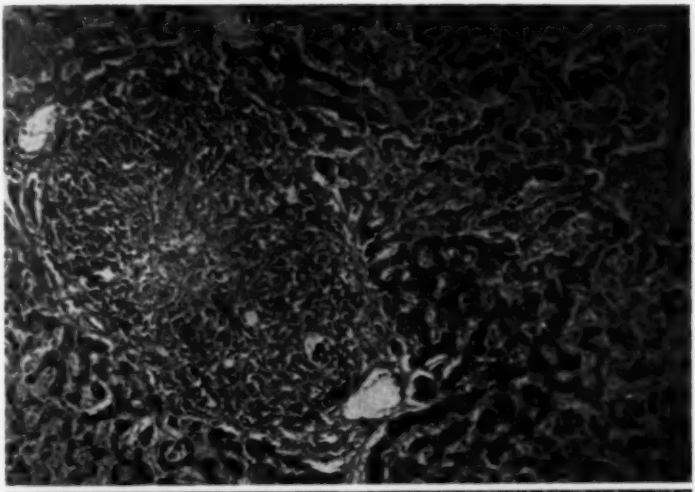

FIGURE 3

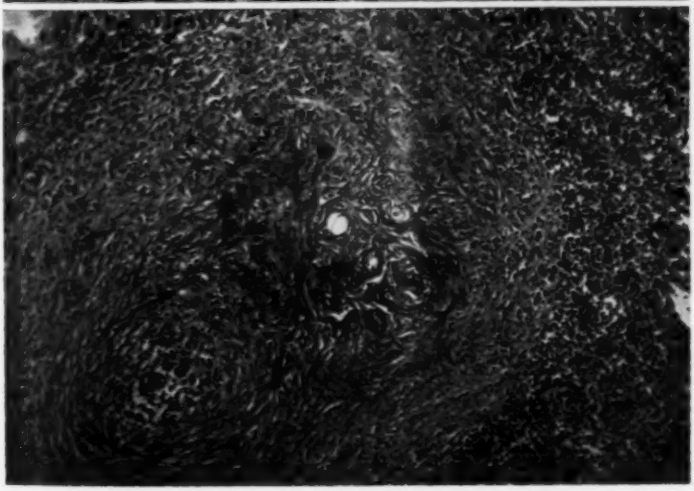

FIGURE 4

FIGURE 3: Liver tissue with granulomatous lesion; note absence of cholesterol clefts.
FIGURE 4: Spleen tissue with marked fibrosis and granuloma formation.

Qualitative and quantitative methods for tissue identification of cholesterol revealed the lung sections to have up to tenfold excess of this lipoid. Chemical methods failed to evidence any silicon dioxide, even qualitatively. Cultures and smears for tuberculosis again were completely negative.

The microscopic examination of the lungs revealed thickened alveolar septa with increased fibrous connective tissue and scattered lymphocytes and eosinophils. Extending into the alveolar lumina were small granulomatous lesions with multinucleated giant cells of a foreign body type, yet not compatible with Langhans' cells. Many of these granulomata filled the alveolar spaces and contained multiple cholesterol clefts in fibrous tissue (Fig. 1). Smaller vessels in the involved areas had intimal proliferation of the endothelium and infiltration with lymphocytes (Fig. 2). These focal vessel changes were most marked in the smaller arteries. The peripheral parenchyma had ruptured septa with coalescence of alveoli. The liver central veins and sinusoids were dilated and an associated central atrophy of the hepatic cord cells was present. Associated with the portal triads were small granulomatous lesions similar to those described in the lung without cholesterol clefts (Fig. 3). Subcapsular granulomata were a prominent feature in the spleen. The lesions were generally associated with arteries and endarteries (Fig. 4). The preaortic lymph nodes exhibited the same granulomatous changes described in the other organs. The adrenal fascicular zone showed decrease of cell volume and lipoid content. Kidney and gastrointestinal tract sections did not have involvement of arteries or parenchyma.

Discussion

Cholesterol pneumonitis was described in the American literature in 1949 by Robbins and Sniffen.[1] Similar cases are described as foam cell pneumonia in 1951 in Germany.[2] Clough[3] discusses an almost identical disease, without cholesterol deposits, as the diffuse interstitial pulmonary fibrosis of Hamman and Rich;[4] and he lists 25 typical cases up to 1954.

The clinical symptoms of this disease are a direct result of increasing fibrosis of lung parenchyma. This interferes with pulmonary gaseous exchange at a capillary level. The patient has little or no respiratory reserve and his oxygen saturation of the arterial blood falls even at rest. The diagnosis can be made only microscopically because clinically the lesion is usually confused with malignancy.

Attempts to explain an origin for the disease have pointed out a similarity to paraffin-oil aspiration pneumonia,[1] periarteritis nodosa,[5] septic vessel disease,[6] and allergic granuloma of the lung.[7] Other authors[8,9] relate it to an allergic granulomatous process with an allergic angiitis. The allergic reaction is probably of low intensity in pneumonitis of the cholesterol type, perhaps due to a small quantity of antigen or antibody or both.

The cause of the sensitization is unknown, although sulfonamides have been associated with cases of acute necrotizing pneumonitis.[10] Bacteriologic and fungal studies have always been negative which supports the hypothesis of a hypersensitivity phenomenon.

When the lesion is localized, surgical removal of the involved tissue is possible. An illustrative case has been reported in the Case Reports of the Massachusetts General Hospital (43412).[11]

The prognosis is grave because fibrosis progresses rapidly. Since the sensitizing agents are unknown, one cannot prevent the progressive diminution of active breathing tissue. The operated cases have shown good results, but long-term follow-up studies are not available.

Corticotrophin and cortisone have been tried in a few cases of fibrosing pulmonary disease.[12,13] These results were encouraging enough to warrant the use of steroids in our patient, although we realized that this disease is similar but not identical to the cases referred to.

ACKNOWLEDGMENT: We would like to express our thanks to the Chief of Medicine Emeritus of Allertown Hospital, Dr. C. H. Kelchner, for his encouragement.

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EFFECTS OF HALOTHANE

The effects of halothane administration upon myocardial contractile force (Walton-Brodie strain gauge arch sutured to the right ventricle) and total vascular resistance were studied in six patients during complete cardiopulmonary bypass. The administration of 2 per cent halothane introduced into the oxygenator resulted in a decrease in myocardial contractile force in every patient. The change in contractile force was linear with time and averaged 28 per cent less than the control value at five minutes. Systemic arterial pressure (total vascular resistance) also fell in five of the six patients and after the period of halothane administration averaged 17 per cent less than the control value. During a ten minute recovery period arterial pressure rose somewhat but a further reduction in contractile force was observed. The observations, made while the heart and peripheral circulation were physiologically separated, indicated that halothane directly depresses the myocardium and the agent also decreases total vascular resistance.

Morrow, D. H., and Morrow, A. G.: "Effects of Halothane on Myocardial Contractile Force and Vascular Resistance," *Anesthesiology*, 22:537, 1961.

BIOLOGICAL EFFECT OF BACILLARY EXOGENOUS MULTIPLE AND SIMULTANEOUS REINFECTIONS IN ANIMALS VACCINATED WITH BCG

The authors tried to induce multiple, simultaneous reinfections in different organs of guinea pigs immunized with BCG. The infecting quantity of 1/20,000 mg. has proved to be unable to take root in immune animals. Simultaneous inoculation of ten similar quantities, divided into as many organs, has proved to be able to colonize and to give place to lymphohematogenous dissemination. They concluded from these experiences that the simultaneous administration of multiple infecting doses (each of them harmless) succeeds in overcoming the immunity induced by vaccination differently from what happens when the quantities are administered consecutively.

Curci, G., Bariffi, F., and Ninni, A.: "Sull'effetto Biologico di Reinfezioni Bacillari Esogene Multiple e Contemporanee in Cavie Vaccinate con BCG," *Arch. Tisiol.*, 16:229, 1961.

Carcinoma Arising in a Congenital Lung Cyst*,**

Report of a Case

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Corpus Christi, Texas

In 1941, Womack and Graham[14] first called attention to the occurrence of squamous metaplasia in the lining of congenital lung cysts. This observation was based upon the study of three cases, which they felt suggested a pathogenetic role for this change in the formation of squamous cell carcinoma. Both prior to and since this article by Womack and Graham, several papers[1-10,12,13,15] have appeared which either cite or report cases of carcinoma associated with lung cysts. However, most of these[1-7,9,12] have been cases of independent bronchial carcinoma in a cystic lung; or they have been so poorly documented that no direct relationship was apparent between a carcinoma and a pulmonary cyst. If one accepts the criticism offered by some authors,[11] there are only three cases[8,10,13] in the English literature in which there is irrefutable documentation of a carcinoma arising in the wall of a congenital pulmonary cyst.

The following case is presented as another example of this occurrence.

Case Report

V.R.L.: This 30 year-old white man cigarette smoker was known to have a solitary right lower lobe cyst, which had been detected on a routine physical examination one year prior to admission (Fig. 1). He had received no treatment and had been asymp-

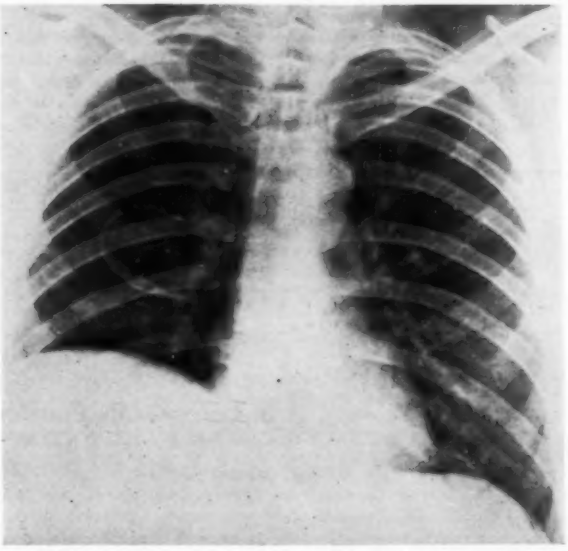

FIGURE 1: Chest roentgenogram taken one year prior to admission showing solitary pulmonary cyst in right lower lobe.

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**The views expressed are those of the author and do not necessarily represent the views of the Bureau of Medicine and Surgery, Navy Department.
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tomatic until one week before his admission to the U. S. Naval Hospital, when he developed an aching pain in the right posterior aspect of the chest.

The physical findings were essentially normal except for tenderness over the posterior portion of the right sixth through eighth ribs. Chest roentgenograms revealed a single cyst in the superior portion of the right lower lobe. Comparison with the previous film (Fig. 1) showed no change in the size or configuration of the cyst.

Right thoracotomy was performed, at which time the lower lobe was found to be adherent to the seventh rib posteriorly. A frozen section of the lung revealed an oat cell carcinoma. Right lower lobectomy was performed.

The surgical specimen disclosed a thin walled spherical cyst located between the posterior basal and lateral basal segments. The cyst measured 8.0 cm. in diameter. On the postero-lateral wall of the cyst there was a firm greyish-white tumor nodule which measured 1.0 cm. in greatest diameter (Fig. 2). The tumor infiltrated the adjacent lung, where it had been separated from the rib cage. There were four small communications between the cyst and the bronchial tree; however, there was no bronchus related to the tumor. All of the major bronchi of the lobe were unremarkable.

Microscopic sections revealed the cyst to be lined with typical bronchial epithelium (Fig. 3). The cyst wall was composed of a thin layer of chronically inflamed fibrous tissue and rare smooth muscle elements. The tumor, which arose from the lining of the cyst, was composed of well differentiated squamous cell carcinoma (Fig. 4) mixed with areas of oat cell carcinoma. The tumor infiltrated the surrounding lung tissue and pleura. A hilar lymph node contained metastatic squamous cell carcinoma.

The immediate postoperative course was uncomplicated. Because of the local rib invasion and hilar node spread, x-ray and nitrogen mustard therapy were instituted. His condition deteriorated progressively and he expired seven months after admission.

Postmortem examination revealed a large tumor mass in the right hemithorax. The tumor infiltrated the third through the eighth vertebral bodies and the adjoining ribs and soft tissues. There were distant metastases in the hilar lymph nodes, both adrenal glands and liver. On microscopic study all of the tumor tissue was found to be composed of poorly differentiated squamous cell carcinoma.

Comment

This case bears out the contention of Womack and Graham[15] and Graham[2] that the bronchial epithelium of congenital lung cysts can give rise to squamous cell carcinoma. Perhaps the development of carcinoma should be considered as a possible complication when planning the management of a case of congenital lung cyst. This consideration might serve as another indication for surgical intervention in these cases.[6]

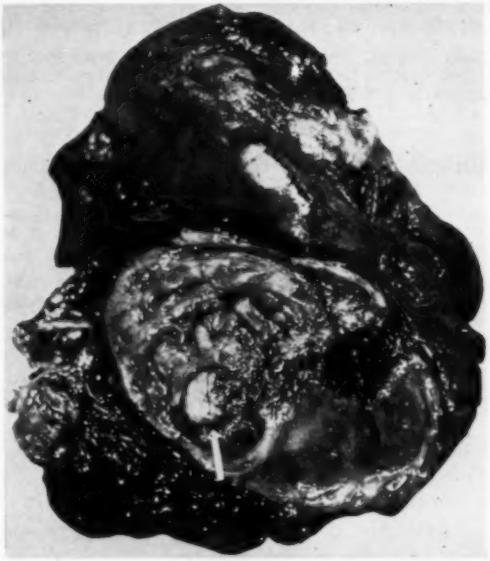

FIGURE 2: Lung cyst showing squamous cell carcinoma (arrow) arising in the wall.

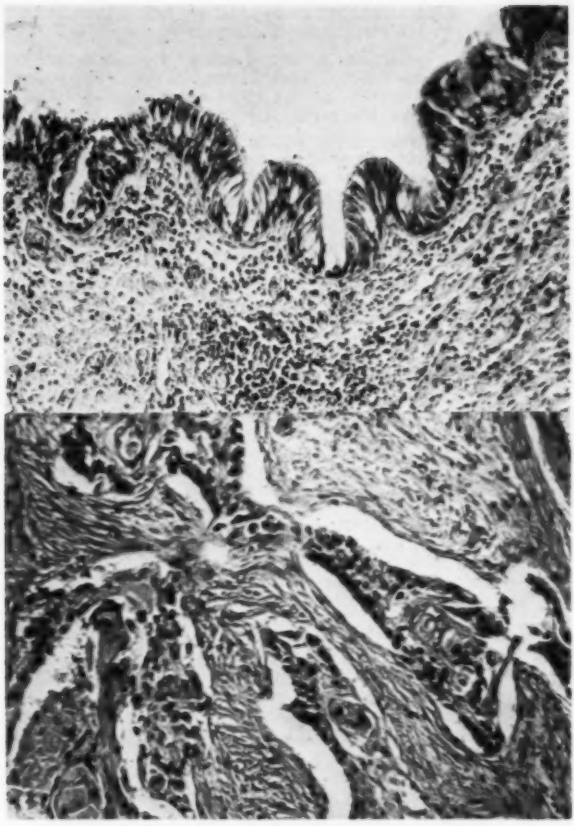

Figure 3

Figure 4

FIGURE 3: Section through cyst wall showing typical bronchial epithelium. (H. and E. X200). FIGURE 4: Section through tumor mass showing well differentiated squamous cell carcinoma. (H. and E. X200).

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OPISTHORCHIASIS WITH PULMONARY INVOLVEMENT

The diagnosis of opisthorchiasis in this case was established by the repeated finding of the ova in the feces. The pulmonary lesion in the right lower lung field, with greenish sputum which showed a positive bile test, suggested a connection with the biliary tract. *Alcaligenes faecalis* found in the sputum was interpreted as a secondary invader. The introduction of radiopaque substance into the liver showed finger-like dilatations of the biliary tract. This is typical of advanced cases of opisthorchiasis. The radiopaque substance was also found in the lower lung field, suggesting the presence of a connection between the liver and the lesion in the lung. This was confirmed at necropsy. A thorough search of the available literature fails to disclose any previously reported case of intrathoracic opisthorchiasis diagnosed ante-mortem.

Prijyanonda, B., and Tandhanand, S.: "Opisthorchiasis with Pulmonary Involvement," *Ann. Int. Med.*, 54:795, 1961.

COMPARATIVE STUDIES OF PROTOVERATRINE A AND PROTOVERATRINE B INTRAVENOUSLY IN HYPERTENSIVE MAN

Comparative studies of intravenously administered protoveratrine A and protoveratrine B in hypertensive man indicate that the alkaloids have qualitatively similar hypotensive, bradycrotic and emetic actions, but quantitatively different hypotensive and emetic potency. Protoveratrine B was better tolerated than protoveratrine A. Indeed, protoveratrine B had little emetic activity when given intravenously in doses producing nomotension. Protoveratrine B appears to have properties that warrant its preferential selection for parenteral administration. The strong hypotensive activity of intravenously administered protoveratrine B, its development of maximal action within minutes, and its pulse-slowing effect favor its use in those hypertensive states in which almost immediate lowering of the blood pressure is indicated.

Winer, B. M.: "Comparative Studies of Protoveratrine A and Protoveratrine B Intravenously in Hypertensive Man," *Circulation*, 22:1074, 1960.

ROENTGENOGRAM OF THE MONTH

Edited by Benjamin Felson, M.D.

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Clinical History

A 38 year-old housewife accompanied a friend to have a photoroentgen film and decided to have her own taken. She was entirely asymptomatic and gave no history to suggest pulmonary, cardiac, thyroid or gastrointestinal disease. A chest film four years previously had been reported as normal.

Physical examination revealed an apparently healthy young woman. Vital signs were normal. The thyroid gland was barely palpable, but not thought to be significantly enlarged, and demonstrated no substernal extension clinically. Routine laboratory studies were normal, as was serum protein-bound iodine. Radioactive iodine uptake and scanning showed normal uptake in the thyroid gland without evidence of ectopic functioning thyroid tissue.

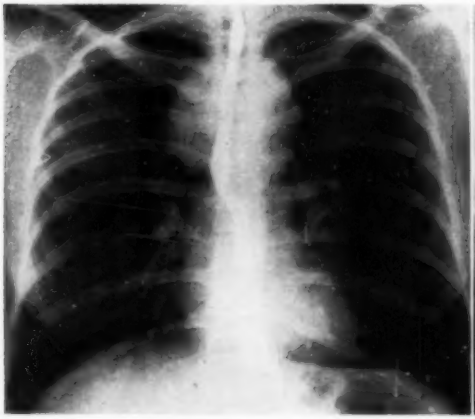

FIGURE 1

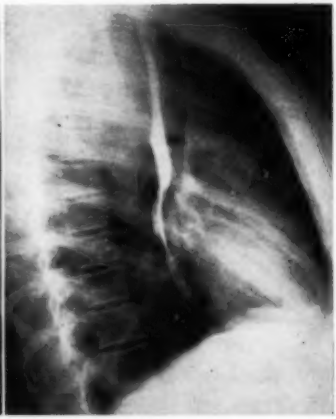

FIGURE 2

Answer: MULTILOCULATED CYST OF THE THORACIC DUCT

Discussion

Roentgen examination of the chest revealed a well-defined, smoothly lobulated mass in the superior portion of the mediastinum, displacing the trachea and esophagus slightly forward. The mass did not pulsate nor did it move on deglutition. Diaphragmatic motion was normal.

Right thoracotomy was carried out. A lobulated, soft cystic mass was present in the mediastinum. The thoracic duct entered the mass, and the mass contained chylous fluid. It was excised along with suture-ligation of the thoracic duct. Histologically, abundant smooth muscle was seen to be present in the cyst wall, and the possibility of leiomyomatosis of the thoracic duct was raised. Postoperative course was uneventful and the patient has remained well for the intervening two-year period.

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SECTION ON CARDIOVASCULAR DISEASES

Left Bronchial and Pulmonary Changes in Mitral Stenosis

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New York, New York

In their excellent papers on distortion of the bronchi by left atrial enlargement, Steele[1] and Steele and Patterson[2] reviewed the literature of nearly a century on the subject and added significantly to it. They concluded that in mitral stenosis compression and displacement of the bronchi by left atrial enlargement occurs frequently and could be demonstrated by x-ray, but rarely gives rise to lung changes. With the development of angiocardiographic methods, Robb and Steinberg[3] and later Dotter and Steinberg,[4] confirmed these x-ray film and fluoroscopic findings and also pointed out the importance therein of the engorged pulmonary veins. Schwedel[5] emphasized that when left atrial enlargement occurs later in life bronchial compression is less likely and only elevation results.

Though mention is always made of elevation of the left bronchus in mitral stenosis in current text books on cardiology little or no mention is made of the bronchial obstructive manifestations due to dilatation of the left atrium and pulmonary veins. Recently, however, Edwards[6] in the presentation of an autopsy specimen did clearly demonstrate such effects due to pressure of a dilated left atrium on the left bronchi causing impaired drainage with resulting infection of the left lung.

For the past ten years in the course of the medical selection of cases of tight mitral stenosis for valvotomy I have been impressed by the frequent occurrence of a history of chronic bronchitis, not due to cardiac failure, but several times labeled allergic or true bronchial asthma. One such patient with considerable bronchitic manifestations, and bronchiectasis chiefly in the left lower lobe, required lobectomy which was performed at the time of the valvotomy. Subsequently several patients were observed with tight mitral stenosis and marked "bronchitis" also requiring bronchography. The purpose of this paper is to describe the distortion of the left main bronchus and its probable effect on the left lung in these cases of tight mitral stenosis.

Case 1 (previously reported in detail[7]): M. G. was a 52 year-old white woman with rheumatic heart disease, enlarged heart, tight mitral stenosis, mild mitral regurgitation, atrial tachycardia, Class IV E, and chronic bronchiectasis—also diabetes mellitus and cholelithiasis. There had been a history of chronic cough with mucopurulent expectoration for about 15 years, thought to have an allergic basis; also of repeated pneumonitis. Wheezes and rales were heard throughout the lungs more at the bases and especially on the left side, present also when cardiac failure was minimal or absent. On fluoroscopy and x-ray films the cardiac silhouette showed prominence

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of the pulmonary artery segment. Against the barium filled esophagus the impression by the left atrium indicated moderate enlargement. There was only slight ventricular systolic pulsation of the left atrial border. The right ventricle appeared enlarged. Because of the prominent pulmonary findings, a bronchogram was made (Fig. 1). It revealed distortion of the left main bronchus and the presence of extensive saccular bronchiectasis in all segments of both lower lobes, more on the left. The angle between the two main bronchi was 70°; between the left main bronchus and trachea 45°, but due to elevation beginning 2.5 cm. from its origin there was an additional elevation angle of 30° here. Also 3 cm. from its origin the lumen appeared narrowed, being 1 cm. in diameter compared to 1.5 cm. for the right main bronchus at 3 cm. from its origin, a disparity greater than normal. At operation the mitral orifice was small and slit-like with some regurgitation; the left atrium was greatly enlarged. A large amount of secretion emanated from the left lower lobe. Mitral valvotomy and lobectomy of the left lower lobe were performed. The lung specimen showed some narrowing of lumen of the left main bronchus. Anterior, posterior and lateral basal bronchi were all dilated and filled with viscid white secretion. The pulmonary arteries showed considerable thickening of the musculature and narrowing of the lumen. The smaller arteries also had considerable hypertrophy of the muscular layer and subintimal deposition of lipid material. There was thickening of the alveolar septa. The patient is alive and has been working regularly for the past four years to date of writing. Some symptoms of bronchiectasis (right lung) persist.

Comment: This case demonstrated marked bronchitic symptoms in a patient with mitral stenosis, starting quite early and ending in bronchiectasis, probably due to early compression of left main bronchus with impairment of drainage and resulting infection of left lower lobe (bronchiectasis).

Case 2: A. K. was a 40 year-old white woman admitted to Beth Israel Hospital for the sixth time, June 25, 1955. She had several attacks of chorea in childhood, had tight mitral stenosis, and had been in congestive heart failure, twice with pulmonary edema. There was a history of several attacks of viral pneumonia, and of coccidioidomycosis in 1951 in Phoenix, Arizona.

She complained of moderate dyspnea, orthopnea, mild ankle edema, cough, and fatigue. Coarse rales were heard over both lung bases. The ECG revealed atrial fibrillation, vertical electrical position, the frontal mean QRS axis was at plus 77 degrees; rsr′ in V1, plus 1, minus 2, plus 1 mm.; the QRS transitional precordial zone between V3 and V4; R in V5 plus 22 mm. Fluoroscopy corroborated the presence of a huge left atrium and marked right ventricular enlargement without significant enlargement of the left ventricle. In the left anterior oblique position both elevation and compression of the left main bronchus were visualized. In the bronchogram (July 5, 1955), posteroanterior projection, the angle between the two main bronchi was 82°, the angle between the left main bronchus and trachea 57°. At 3 cm. from its origin there was a gradual but substantial elevation and also considerable narrowing of lumen of the left main bronchus compared to the right (Fig. 2). The smaller bronchi appeared normal in size, but there was crowding of the structures. Bronchiectasis was not evident. At operation, July 12, 1955, there was enlargement of the left atrium and right

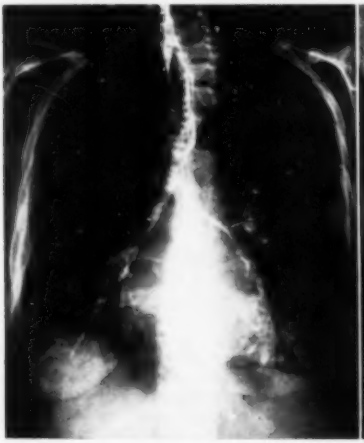

FIGURE 1

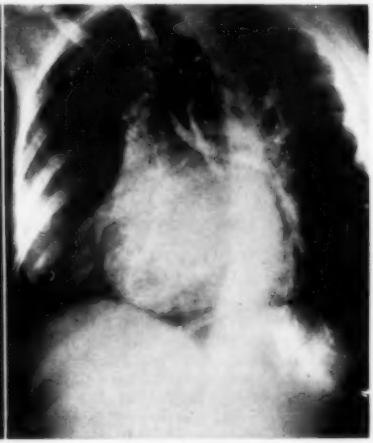

FIGURE 2

FIGURE 1: Case 1. Bronchogram; also barium in esophagus. See text. FIGURE 2: Case 2. Bronchogram; left anterior oblique; enlarged left atrium, elevated and compressed left bronchus.

ventricle; no atrial thrombi; the mitral valve orifice did not admit the finger tip. After the commissurotomy, her recovery was uneventful. She has returned to Arizona, is feeling well at present and the "bronchitis" has disappeared.

Comment: This was a patient with tight mitral stenosis who had marked bronchitic symptoms and several attacks of pneumonia. She had a very large left atrium with striking elevation and compression of the left main bronchus. Rales and bronchographic changes at the left lung base considered due to parenchymal changes were present. Disappearance of the bronchitic symptoms and signs after valvotomy suggested that obstruction with impairment of drainage from left lung base had been the cause.

Case 3: C. C. was a 29 year-old woman with symptoms and signs of tight stenosis. X-ray films, August 28, 1952, revealed considerable enlargement of the left atrium, slight enlargement of the right ventricle and pulmonary artery, and no enlargement of left ventricle. Only slight ventricular systolic pulsations of the left atrial border against the esophagus were seen, and no cardiac calcifications. In the ECG the frontal mean QRS axis was at plus 72°. At operation, March 13, 1953, a fishmouth-mitral valve was palpated with an opening of 4 mm. in its greatest diameter. A slight regurgitant jet was felt. After fracture two fingers could be admitted into the valve opening. There was an excellent subjective and clinical improvement following the valvotomy. Four years later, on June 29, 1957, she was readmitted to the hospital because of an attack of chills and fever the previous night. She had been having a chronic cough for two years, productive of whitish sputum, and had been told the cough was caused by her "auricle pressing on a bronchus." Grade 3 systolic and grade 1 to 2 mid-diastolic and presystolic murmurs were heard at the mitral area. An opening snap was not heard. Because of fever, chills, splenomegaly, microscopic hematuria and leucopenia, subacute bacterial endocarditis was suspected and though blood cultures were negative a course of antibiotic therapy was given. On fluoroscopy, August 14, 1957, and x-ray films, August 18, 1957 (Dr. A. Geffen), the left atrium appeared slightly enlarged against the barium filled esophagus, the left main bronchus not elevated or compressed. Indirect laryngoscopy disclosed a small polyp of the right vocal cord, believed by some the cause of the coughing.

In the bronchogram, August 16, 1957, (Fig. 3) the left main bronchus appeared normal. There was no evidence of bronchiectasis. The angle between the left main bronchus and trachea, postero-anterior view, was 37°, the total interbronchial angle 57°.

Comment: This patient with tight mitral stenosis relieved by valvotomy, two years later developed a chronic cough. The lungs were clear. Cardiac fluoroscopy and x-ray films revealed some enlargement of the left atrium. The left main bronchus did not appear elevated or compressed. A bronchogram revealed normal angle between the left main bronchus and trachea, and normal lung pattern. On endoscopy laryngeal polyps were found.

Case 4: S. B., a 48 year-old white man with rheumatic heart disease was admitted to this hospital on July 20, 1959, because of congestive heart failure and "asthma." It was his tenth and final admission. In childhood he had scarlet fever and several attacks of rheumatic fever with joint symptoms, and "asthma." The first hospital admission, November 2, 1952, and most subsequent ones were for "asthma" and/or

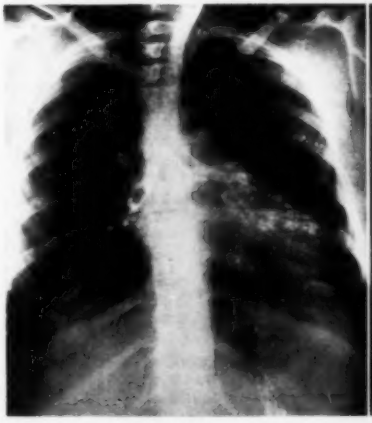

FIGURE 3

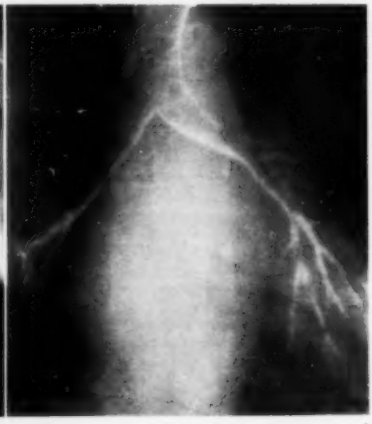

FIGURE 4

FIGURE 3: Case 3. Bronchogram. See text. FIGURE 4: Case 4. Bronchogram. Displacement and compression of left main bronchus.

cardiac failure. November 2, 1952 the venous pressure in an antecubital vein was 180 mm. saline, rising to 250 mm. on right upper quadrant pressure; circulation time (Decholin) was 34 sec., ether time (arm to lung) 17 sec. With therapy for cardiac failure these hemodynamic deviations returned to normal. On the third admission, April 1, 1953, the venous pressure was 200 mm. rising to 340 mm. on right upper quadrant pressure, and in 1954 (fourth admission) it was 240 mm. rising to 360 mm.; the circulation time (decholin) was 30 sec. Because of the findings of predominant mitral stenosis, atrial fibrillation with recurrent and progressive cardiac failure, and especially because of an episode of cerebral embolism, a mitral valvotomy was performed, February 17, 1954. Organized thrombi were removed from the left atrial appendage. The posterior leaflet of the mitral valve was calcified. The mitral orifice admitted one and one-half fingers. It was enlarged digitally to two fingers. Moderate mitral regurgitation present initially became somewhat less after valve fracture. Following the commissurotomy there was substantial clinical improvement including almost complete disappearance of the cough and expectoration, until two and one-half years later when signs of cardiac failure reappeared and also the asthmatic attacks. With rest, dietary and medicinal therapy for cardiac failure, also Alevaire and Isuprel, he improved. On the ninth admission, July 6, 1959, such therapy induced a 36 pound weight loss in 11 days. However, the auscultatory signs of tight mitral stenosis—the auscultatory fout-ta-ta-rou—substantially decreased after valvotomy, had now returned with a loud M1, a sharp opening snap close to M2 and a long loud diastolic rumble with seemingly terminal crescendo. The venous pressure was 270 mm. rising to 480 with right upper quadrant pressure, the circulation time (decholin) 40 sec. The electrocardiogram showed increasing right axis deviation; the frontal mean QRS axis was at plus 95°. The sum of maximum negative right and positive left precordial lead voltages was 3.4 millivolts. An angiocardiogram, November 14, 1956, had shown visualization of the left atrium up to 14 sec. after antecubital injection.

After subsidence of the cardiac failure a right heart catheterization was performed, July 16, 1959. Pressures were: R.A. 6 mm.Hg., R.V. 50/4, M.P.A. 49/28, B.A. 77/55. Because of the patient's distressful reaction this procedure had to be curtailed, and for similar reasons at a later date left heart catheterization, though started, could not be completed. At this time the clinical and roentgenologic findings (to be described later) were interpreted as indicative of restenosis of the mitral valve. A grade 2 to 3 apical systolic murmur suggested some mitral regurgitation, noted at the cardiac surgery in 1954, however, at present not considered of sufficient amount to contraindicate operation thought desirable for the dominant and symptomatic stenosis. Fluoroscopy and x-ray films, July 23, 1959, revealed considerable enlargement of the cardiac silhouette in the transverse diameter, to the right and left, with double density of shadows on the right, prominence of the pulmonary artery segment, enlargement of the right ventricle, huge left atrium and slight enlargement of the left ventricle; also calcification of the mitral valve. The hilar and peripheral pulmonary vascular shadows were prominent with changes of chronic congestion and also of hemosiderosis. Because of the marked bronchitic manifestations—cough and profuse expectoration with rhonchi, wheezes and rales in the lungs—a bronchogram was made August 10, 1959. Taken with the patient erect it demonstrated elevation of the left main bronchus with backward displacement and narrowing of the lumen due to left atrial enlargement, pulmonary emphysema, and fibrosis; no bronchiectasis (Fig. 4).

In the postero-anterior view the interbronchial angle was 90°. There was gradual and substantial elevation of the left main bronchus beginning 2 cm. from its origin; the luminal radiolucency was reduced; it measured 0.7 cm. in diameter compared to 1.2 cm. for the right bronchus—more than the normal disparity. At operation, August 13, 1959, the mitral orifice was small just admitting one finger with difficulty; the valve edges were thickened and rolled, the postero-medial commissure was heavily encrusted with calcium. Considerable hemorrhage occurred. The blood was replaced, but the blood pressure failed to respond adequately. Ventricular tachycardia developed. The commissurotomy was carried out hoping that the added blood flow to the left ventricle would be helpful. However, ventricular tachycardia continued, was followed by ventricular fibrillation and in spite of the many emergency measures for restoration of adequate circulation permanent cardiac arrest ensued. At necropsy, the heart was enlarged, weighing 450 gm. There was marked dilatation of the right ventricle, also the right atrium and left atrium with slight if any enlargement of the left ventricle. The right ventricle measured up to 0.7 cm. in thickness, the left to 1.5 cm. The mitral valve orifice (reconstructed) was greatly narrowed, rigid and slit-like with little insufficiency. The posterior cusp was calcified. The lumen of the left main bronchus was moderately narrowed especially at 2 cm. from its origin. The mucosa was congested and contained a small amount of hemorrhagic mucoid material. On section the pulmonary parenchyma was red gray and a slight amount of frothy fluid was expressed on the cut surface. A few granular areas were noted. In the non-aerated left lung some branches of the pulmonary artery contained agonal thrombi. On microscopic examination many of the alveolar spaces were filled with hemosiderophages and clusters of free brown pigment. There were some interstitial round cell infiltrates.

Comment: This 48 year-old man had tight mitral stenosis and a history of asthma. At 42 years a mitral valvotomy was performed chiefly because of evidence of emboli from thrombi in the left atrial appendage. The mitral stenosis and regurgitation were

both reduced, and marked clinical improvement followed with relief of the bronchitis and "asthma." Later evidence of restenosis of the mitral valve occurred with return of the bronchitic and asthmatic manifestations. Bronchography revealed displacement and narrowing of the left main bronchus. Operation for restenosis was performed but he did not survive. At necropsy there were distortion and narrowing of the left main bronchus and parenchymal changes in the left lower lobe which were thought to be due, at least in part, to the definitive changes in the left main bronchus.

Discussion

The frequent occurrence of chronic bronchitis and left basal pulmonary changes in patients with mitral stenosis is well known. The pathogenesis is not clear. Though little support is given to the concept of their production by compression of a main bronchus, this mechanism had been described as early as 1838, by King.[8] Coombs[9] readily conceded the possibility of such a cause for the changes and the physical signs over the affected lung in his clinical cases.

Steele[1,2] and Stoerk[10] found the minimal angle of tracheal bifurcation in their patients with mitral stenosis to be 78° with none higher among the normal subjects. Kahler[11] in his bronchoscopic observations on the stenosis of the left main bronchus in 12 patients with mitral disease included one with the lumen reduced to 2 mm. In 1937 with iodized oil (Lipiodol) studies on 15 patients with diseases of the mitral valve, Routier and De Balsac[12] observed marked reduction of caliber of bronchi especially the left, to as little as one-third or one-fourth of their normal dimensions.[11]

Roesler[13] called attention to the considerable normal variation of the main bronchial branches. He also indicated that in the course of bronchitic mucous membrane swelling, considerable narrowing of lumen may occur with resulting atelectasis of the base of the left lung and that this has sometimes been erroneously interpreted as pneumonic consolidation.

Paul Wood[14] noted that recurrent attacks of winter bronchitis occur in about one-third of cases of well developed mitral stenosis. He believed the turgid or edematous state of the bronchial mucosa was due to high bronchial venous pressure and was responsible for the severity of these symptoms if not for the susceptibility to infection although a convincing relationship between the frequency of bronchitis and the height of the left atrial pressure could not be demonstrated statistically. Little role was attributed to splaying of either bronchus or to compression of the left bronchus in the syndrome. However, he did note that both chronic cough and bronchitis may result from compression of the right or left main bronchus from aneurysmal dilatation of the left atrium.

The four cases described in this paper are illustrative of the bronchial and pulmonary changes of tight mitral stenosis and of problems in their diagnosis, explanation, and treatment. Though the frequent presence of distortion of the main bronchi, and of pulmonary parenchymal changes, at least in the more severe cases, is well known, the entire nature of this distortion and its effect on the lung tissue which this bronchus serves have not been fully elaborated, and about the latter there has been much difference of opinion.

Anatomic studies in normals indicate the presence of some fixation at the lower end of the trachea;[15] however, displacement of the trachea at the site of bifurcation and of the right and left main bronchi in patients with mitral stenosis may be considerable. First (not necessarily in order of appearance) is the increased separation or splaying of the two main bronchi starting at their origin. This is a regular occurrence in patients with mitral stenosis with significant enlargement of the left atrium as has been shown by Stoerk.[10] It may be marked as in Fig. 2 and in extreme cases the interbronchial angle may be up to 180°.[12] (2) Elevation of the bronchi occurs (a) at the site of the tracheal bifurcation and thus including the terminal trachea as well as the proximal portion of one or both main bronchi, especially the left; and (b) additional elevation of the left main bronchus starting at 2 to 3 cm. from its origin. The latter may be marked and either gradual or sharply formed. In Case 1, it was 30°. The two elevations of the left main bronchus may result in a configuration resembling an S lying on its side.[1] Illusion of such elevation may be due to failure to visualize the first inferior branch of the left main bronchus.

(3) Backward displacement of the left main bronchus may also take place.[5,12] This was observed in Case 2 in the bronchogram taken in the left lateral position.

(4) Compression of the left main bronchus and narrowing of its lumen are related to the same factors concerned with displacement. Additional factors are thickenings of the wall of the bronchus with encroachment on the lumen due to (a) congestion, edema and transudation produced in the first and second division bronchi by bronchial venous hypertension secondary to right ventricular failure, or in smaller bronchi to pulmonary venous hypertension and to left ventricular failure where these bronchial veins drain more or exclusively into the branches of the pulmonary veins,[17] or the combination of right and left sided heart failure. Such congestive changes in the bronchial walls may be the chronic bronchitis of tight mitral stenosis, thus different from the common infectious type seen in non-cardiac patients; (b) inflammatory changes in the bronchial wall secondary to repeated attacks of infectious bronchitis which may decrease its lumen; (c) thrombosis of the bronchial arteries and veins,

and emboli in the bronchial arteries; (d) changes in the pulmonary arteries, veins and their branches, though the mechanism for producing the alterations in the wall of the main bronchus is unclear at present.

Further reduction of the lumen of the left main bronchus (and its branches) may be brought about by secretions on its surface, due to infection, bronchitis; to the bronchial and pulmonary vascular disturbances mentioned, and to other damage to the ciliary mechanism for their drainage and expulsion.

The degree of the resulting deformity of the left main bronchus therefore need not be strictly proportional to the degree of stenosis of the mitral orifice.

Pulmonary parenchymal changes in the left lower lobe present in all severe cases of mitral stenosis have been well described.[19-24] They may be attributed to (1) direct pressure effects—compression by a large heart and so proportional to the degree of cardiac enlargement in the direction of the left lower lobe; (2) increase in pressure in the pulmonary veins behind an obstructing mitral stenosis in the sense of producing lesser or greater degrees of pulmonary edema; or due to mitral regurgitation or left ventricular failure; the whole lung may then be affected, but because of the compression mentioned above and postural factors the effect on the left lower lobe is greater; (3) increase in pressure in the bronchial veins behind increase in pressure in the azygos system and right atrium due to right sided heart failure may be responsible for changes in the left basal pulmonary parenchyma. This can come about (a) through production of left sided pleural effusion (in the presence of right sided effusion, or of diffuse right sided obliterative pleurisy).[25] It can occur (b) through the production of pulmonary interstitial edema and fibrous changes, either from elevated pressure in the bronchial veins and their venous plexus, or in the pulmonary venous plexus and veins connected with the bronchial veins. The latter probably holds more for the "true" bronchial veins than for the pleuro-hilar group which are thought to anastomose with the pulmonary veins to a lesser degree.[21] However, the precise drainage and hydrodynamics of the bronchial venous system and the pressures in the sinuous bronchial arteries, are yet to be fully and accurately measured. Furthermore there is some confusion because of the different use of the term "true" bronchial veins.[17,21,26] The bronchopulmonary vascular shunts too, which are greater in mitral stenosis, with more decompression effects—remain to be estimated more satisfactorily;[27,28] (4) infections involving the lower lobe such as ordinary bronchitis, bronchiectasis, pneumonia, and "rheumatic pneumonitis;" (5) arterial and venous thrombi, and arterial emboli, with secondary parenchymal changes and infarction of the left lower lobe; (6) finally, and possibly of some importance in some cases of tight mitral stenosis, are pulmonary parenchymal changes due to diminution of air conduit through the narrowed left main bronchus. Changes in the lung are known to result from such reduction of lumen and partial occlusion of the left main bronchus in mitral stenosis[8] as in cases of foreign body, tumor, tuberculosis, and aneurysm of the aorta, (the "aneurysmal phthisis" of Osler and Ross).[29]

Reduction in lung compliance due to pulmonary structural changes secondary to mitral stenosis is also a cause for reduced air flow through the bronchi.[24,30] Under experimental conditions in the rat, dog and in man, airway conductance has been shown to be approximately linearly related to the degree of inflation of the lungs.[30] Reduced air flow with hypoventilation and collapse of some alveoli, plus impairment of drainage of secretions distal to the left main bronchus provide a setting favorable to recurrent or chronic infectious bronchitis, bronchiectasis and pneumonitis.

SUMMARY AND CONCLUSIONS

Displacements, compression, and structural changes of the left main bronchus, recurrent bronchitis and left basal pulmonary changes occur in patients with tight mitral stenosis.

Four cases illustrative of these conditions with problems of diagnosis, pathophysiologic interpretation and treatment are reported.

Explanations of the mechanism of bronchial air, vascular, and parenchymal alterations in patients with tight mitral stenosis are discussed. Though some are reported, the need for more experimental and clinical studies of air and blood pressures and flow in the lungs are indicated to better elucidate the interesting and striking clinical findings in the bronchi and lungs in mitral stenosis.

ACKNOWLEDGEMENT: The cardiac surgery in all four cases was performed by Dr. I. A. Sarot to whom I am indebted for the operative findings.

ADDENDUM: Since this paper was submitted for publication, the excellent article "Effects of Pulmonary Hypertension on the Tracheobronchial Tree" by Jesse E. Edwards and Howard B. Burchell appeared in *Diseases of the Chest*, September, 1960. It emphasized compression of the left main bronchus from above by the pulmonary artery in the presence of pulmonary hypertension.

RESUMEN

En los enfermos de estenosis mitral se observan cambios consistentes en desplazamientos, compresión y alteraciones estructurales del bronquio-principal izquierdo,

asi como bronquitis recurrente y alteraciones en la base del pulmón izquierdo, cuando la estenosis es acentuada.

Se relatan cuatro casos demostrativos de estas condiciones, asi como los problemas de diagnóstico.

Aunque se han relatado algunos estudios se necesitan mas de orden experimental y dinámico de las presiones del aire y del flujo de él en los pulmones para aclarar mejor los hallazgos clínicos en los pulmones y en los bronquios en la estenosis mitral.

RESUMÉ

Déplacements, compression et changements de structure de la bronche souche gauche, bronchite récidivante et altérations pulmonaires de la base gauche peuvent survenir chez les malades atteints d'une importante sténose mitrale.

L'auteur rapports quatre cas illustrant ces conditions avec les problèmes de diagnostic, d'interprétation anatomo-pathologique et de traitements qu'ils comportent.

L'auteur discute les différentes théories qui expliquent les troubles de l'aération bronchique, les altérations vasculaires et parenchymateuses chez les malades qui ont une importante aténose mitrale. Bien que l'auteur présente quelques résultats, il est nécessaire de pratiquer de nouvelles études expérimentales et cliniques de la pression et du débit du sang et de l'air pour mieux comprendre les découvertes intéressantes et frappantes concernant les bronches et les poumons en cas de sténose mitrale.

ZUSAMMENFASSUNG

Verlagerungen, Kompression und strukturelle Veränderungen des linken Hauptbronchus, rezidivierende Bronchitis und linksseitige basale pulmonale Veränderungen traten bei Kranken auf mit verengter Mitralstenose.

Es wird über 4 Fälle berichtet, die diese Krankheitszustände anschaulich machen mit samt dem Problem der Diagnose, der pathophysiologischen Deutung und Behandlung.

Besprechung der Erklärungen des Mechanismus der Veränderungen der bronchialen Luftwege, der Gefäß-und Parenchymveränderungen bei Kranken mit einer solchen Form von Mitralstenose. Obwohl bereits einige diesbezügliche Rerichte vorliegen, besteht Bedarf nach weiteren experimentellen und klinischen Untersuchungen der Atemluft, des Blutdrucks und der Durchströmungsverhältnisse in den Lungen, um die interessanten und eindrucksvollen klinischen Befunde an den Bronchien und Lungen bei Mitralstenose besser aufzuhellen.

Complete reference list will appear in the reprints.

GYNECOMASTIA AND BRONCHIAL CARCINOMA

Dr. K. P. Goldman reports a case of bronchial carcinoma unusual in several respects. First, the presentation as an apparently simple spontaneous pneumothorax without other signs of pleural malignancy; secondly, the period of survival without treatment (two and one-half years from the time of presentation); and, third, the gynecomastia which is a rare complication. In this case, the concentration of estrogens in the urine was three times the normal. It is suggested that terminally the tumor may have become estrogen-secreting.

Goldman, K. P.: "Gynaecomastia and Bronchial Carcinoma," *Brit. J. Dis. Chest*, 55:162, 1961.

ACCENTUATION OF NORMAL CURVE OF LEFT MAIN BRONCHUS

Accentuation of the normal curve of the left main bronchus, which may be observed in tomograms between 8 and 11 cm. in the supine position is described. Such accentuation is interpreted as a sign of a bronchiectatic condition in the superior lobe, or in the whole left bronchial system. In the author's opinion, a chronic tuberculous condition is the most frequent cause of the "U" shaped form of the bronchus. The condition is considered secondary.

Volpe, E.: "L'Immagine Stratigrafica ad U del Bronco Principale di Sinistra Patognomonica di Bronchiettasie," *Ann. Med. Sondalo*, 9:157, 1961.

Tuberculosis and Cardiopulmonary Failure*

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Clinical observations on the effect of chronic tuberculosis on the pulmonary circulation are of no recent origin. The Prague School of Physicians was well aware of its significance in clinical practice over 50 years ago. Professor Jaroslav Jedlicka,[1] one of the few direct pupils of Thomayer, can remember the emphasis placed by this great physician on the signs of impending cardiac failure in phthisis. He considered an accentuated second sound over the pulmonary area in chronic tuberculosis to be a bad omen. In a contribution to the discussion on the paper of Thomayer at the Congress of Naturalists and Czech Doctors in 1914, Professor Maixner[2] spoke of an accentuated diastolic sound over the pulmonary artery as a sign of dilatation and rigidity of this artery. The pupils of Thomayer and Maixner developed this observation still further.

Recently, Herles and Widimsky[3] pointed to the increased incidence of chronic and acute cor pulmonale in the post-war years in the face of a continuous fall in mortality from tuberculosis. An analysis of the cause of death in cases of tuberculosis found at necropsy at Bulovka and Thomayer Hospitals in Prague, revealed a definite relationship between cardiopulmonary complications and the new methods of treating pulmonary tuberculosis. The decrease in mortality from tuberculosis as a result of the use of bacteriostatic drugs has, as a consequence, an increase in chronic forms, which may lead to the development of cor pulmonale. Radical surgery is also a major factor in the increased incidence of acute right-sided cardiac failure over that which was recorded in the era of treatment by pneumothorax and thoracoplasty.

Zak and Stejskal[4] studied the pathologic picture on necropsy of 1357 cases of tuberculosis in persons over 40 years of age.

On the basis of these findings, pathologists have requested that cor pulmonale be considered a complication of extensive cavernous and fibrotic pulmonary tuberculosis.[5]

We have made an investigation of cardiopulmonary failure in tuberculosis at the University Clinic for Tuberculosis in Prague over the past 12 years (1946-1957).

Figure 1 shows that *duration of tuberculosis* before admission to the clinic has increased during the past ten years from 2.8 years in 1947 to 7.5 years in 1957. The duration of the disease has, therefore, increased almost threefold. This factor, in concurrence with the observation of Herles and Widimsky, is of no small importance in the increase in cardiopulmonary failure. Chronic cases are admitted repeatedly to the clinic and there is a decrease in patients admitted for the first time and newly diagnosed.

From the total of 6,854 patients with tuberculosis admitted over the past 12 years, 201 died at the clinic, *i.e.* 2.9 per cent as against 5 per cent in the last three years of the war.

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*University Clinic for Tuberculosis, Director, Prof. Jaroslav Jedlicka; dedicated to Prof. Jedlicka on his seventieth birthday, July 30, 1961.

Figure 2 shows the *average age of patients* who died at the clinic. This has increased from 37 years in 1947 to 57.5 years in 1957. Death from tuberculosis at the clinic, therefore, occurs mainly in older people. This is the second factor increasing the incidence of cardiopulmonary failure. This has also been confirmed by Söderholm.[6]

Figure 3 gives a survey of the *forms of pulmonary tuberculosis* in patients who died at the clinic. Chronic cavernous tuberculosis was present in 75 per cent. This is a greater percentage than during the war, when the figure was 70 per cent. Acute pneumonic tuberculosis, miliary tuberculosis and meningitis appear only sporadically in recent years as against an increased incidence in the years 1948 to 1950. From 1954, however, there has been an increase in retractive fibrotic tuberculosis. This is the third factor which may contribute to the increased incidence of cardiopulmonary failure.

Chronic cavernous tuberculosis, however, remains a basic question in the problem of tuberculosis and also holds first place in the causes of cardiopulmonary failure as may be seen from Figure 3. Spread by aspiration and the substitution of the tissue, defects by scarring take place. Retraction occurs, for the most part, in the presence of persistent cavities and the remaining areas of the lung undergo emphysematous changes.

Unilateral post-tuberculous pneumosclerosis with displacement of the intrathoracic organs in a horizontal direction is rare in our series.[7,8] Furthermore, it does not profoundly affect the pulmonary circulation, in contradistinction to cranial displacement of the root of the lung. The latter change was present in more than 10 per cent of cases in this series. In this so-called subclavicular hilum of the lung,[9] distortion of the main branches of the pulmonary artery is found. They become deranged and

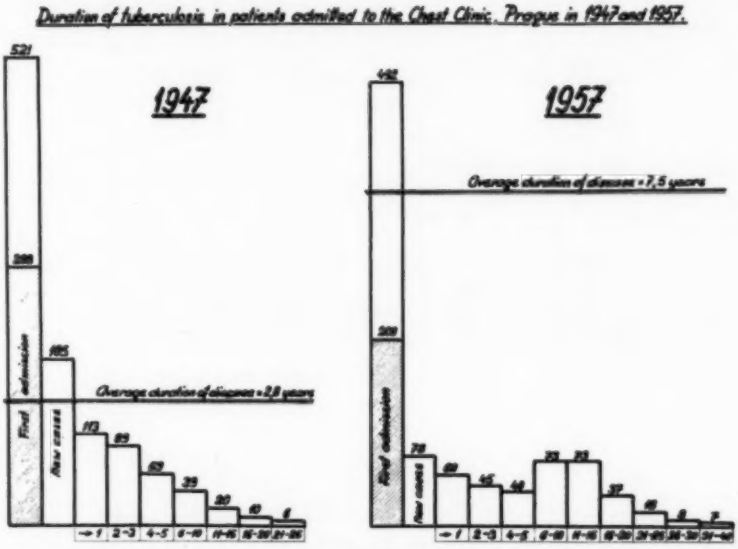

FIGURE 1

narrowed, causing considerable resistance to blood flow, and are a source of vascular murmurs, which are now being studied at the clinic.[10] The existence of these murmurs has also been confirmed by Curti *et al.* in 1955, according to Mira.[11]

Prolonged treatment with bacteriostatic drugs leads to the cleaning up of even large cavities. The thickness of the internal necrotic layer of the cavity is gradually reduced until only a thin-walled sac is left, which looks like a cyst or emphysematous bulla. The cavities are then spoken of as "open healed cavities." In the era before chemotherapy they were observed by Auerbach[12] in only 0.2 per cent of necropsies. On examining excised parts of lung in recent years, they have been found in open healed cavities up to 10 per cent.

Thus, there is an increase in the group of patients with clinically healed tuberculosis with persistent tissue defects, which often, because of their considerable size embarrass the pulmonary circulation, at least to the same extent as cavities healed by scarring.

Figure 3 also shows the number of cases in which clinical signs of cardiopulmonary failure were found and, in the last column, cardiopulmonary failure confirmed at necropsy as the cause of death.

More than half of the patients had clinical signs of cardiac failure before death. Cor pulmonale has been found to be the cause of death at necropsy with increasing frequency in the last four years. It was the cause of death in 23 per cent (46 patients).

Figure 4 gives an analysis of the *individual clinical signs of cardiopulmonary failure* and the corresponding necropsy findings in 100 cases

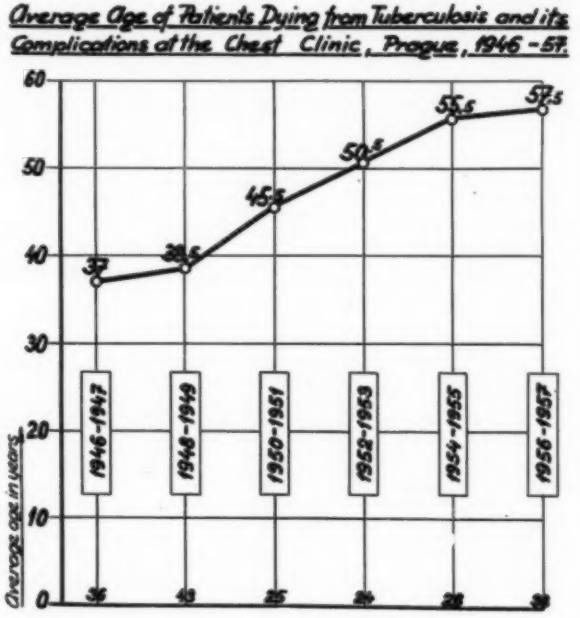

FIGURE 2

with adequate clinical, radiologic and pathologic documentation. All had chronic cavernous pulmonary tuberculosis.

Two-thirds of the patients had a resting pulse rate of over 100. Cyanosis, increased liver dullness and edema of the legs were present in a third of the patients.

In the postero-anterior x-ray film, enlargement of the heart shadow, particularly of the right half, was considered to be present in more than half of the patients.

Cranial displacement of the hilum with dilatation of the main branches of the pulmonary artery, confirmed by tomography, were present in almost a third of the patients. This finding was one of the most reliable radiologic criteria of hypertension of the lesser circulation, which leads finally to right-sided failure.[13]

In the pathologic findings, kindly placed at our disposal by Professor J. Jedlicka, signs of chronic cor pulmonale were, of course, present much more frequently. Hypertrophy of the right ventricle was found in 65

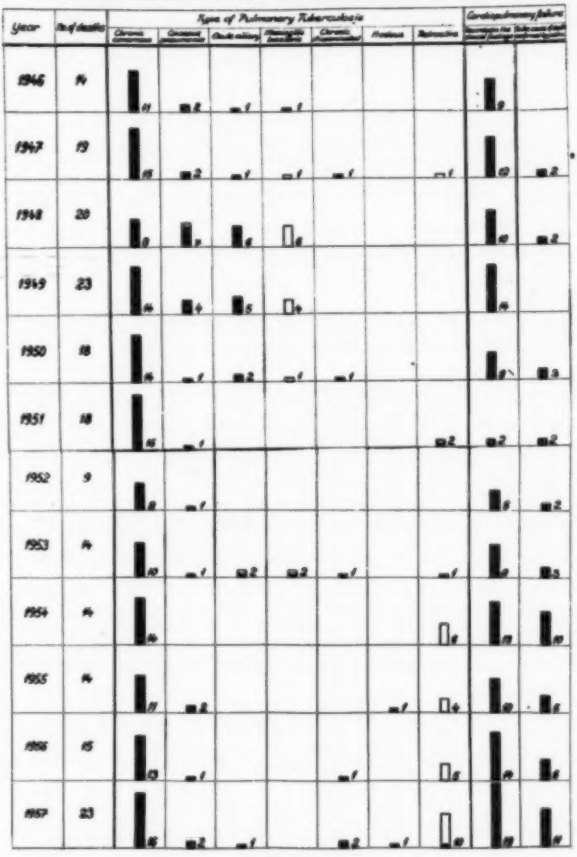

FIGURE 3

per cent, dilatation in 85 and venous congestion of the liver and other organs in 84 per cent.

It is thus evident from the last figure that in two-thirds of the patients where cor pulmonale was found with certainty at necropsy, it was missed on routine clinical examination.

It remains to be seen to what extent incipient or obvious but hitherto compensated cor pulmonale, which Van Loo according to Söderholm[6] considers to be present in 45 per cent of patients with advanced pulmonary tuberculosis, can be diagnosed clinically.

The diagnosis is dependent upon the finding of hypertension of the pulmonary artery. This can be reliably demonstrated by cardiac catheterization, if necessary with occlusion of the main branches of the pulmonary artery for a short period at rest and after exercise, according to the method of Carlens *et al.*,[14] in conjunction with hemodynamic investigation and the estimation of blood gases. These complicated investigations have been made in selected cases of pulmonary tuberculosis (Söderholm,[6] Uggla,[15] Widimsky *et al.*[16,17]). They cannot be made routinely, but such investigations are a necessary starting point for elaboration of simple criteria for the early diagnosis of pulmonary hypertension.

Widimsky *et al.*[16,17] have established the following simple criteria for the diagnosis of compensated chronic cor pulmonale.

III. *Physical examination:*

A. *Signs of hypertension in the lesser circulation:*

1) Palpable second sound over the pulmonary artery.
2) Accentuated second sound over the pulmonary artery with a first sound of equal intensity over the aorta and pulmonary artery.
3) Split second sound over the pulmonary artery with accentuation of its second (pulmonary) part.

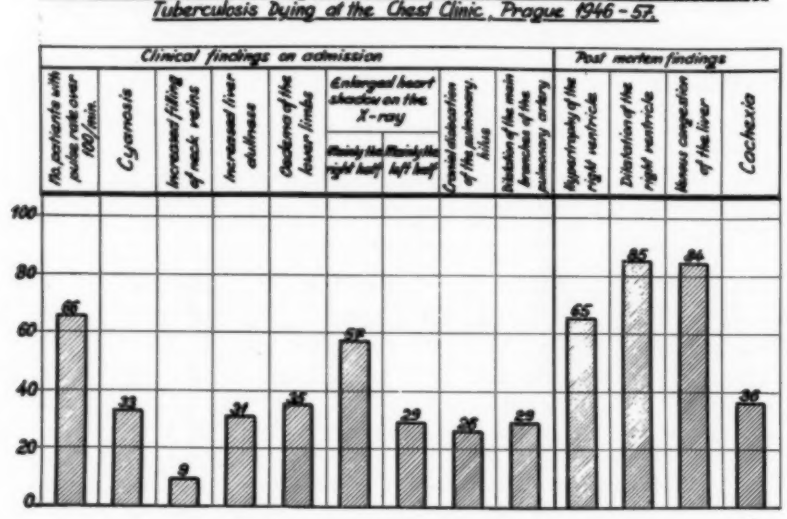

FIGURE 4

4) Diastolic murmur over the pulmonary artery as an expression of functional insufficiency of the pulmonary valves in the presence of dilatation of the pulmonary artery (only in very advanced conditions).
5) Slapping first sound over the pulmonary artery.
6) High "a" wave in the phlebogram of the jugular vein.

B. *Signs of hypertrophy of the right ventricle:*
1) Expansive precordial pulsation.
2) Pulsation of the right ventricle below the xiphoid process.

II. *Electrocardiogram:*
Tracings must be taken from all unipolar chest and limb leads, where necessary with the addition of a lead from the right precordium. Both the direct and indirect signs of cor pulmonale must be taken into consideration.

III. *Radiography of the heart:*
It is necessary to make a comprehensive evaluation of several x-ray signs.
1) Heart shadow of normal or decreased size in the postero-anterior projection.
2) Relative increase in the curve of the right ventricle in the second oblique position.
3) Dilatation of the common trunk of the pulmonary artery in the first oblique position.
4) Dilatation of the main branches of the pulmonary artery in dorsoventral position.
5) Increased difference between width of shadow of main, segmental and subsegmental branches of the pulmonary artery.
6) Active pulsation of the hilar sector of the pulmonary arteries.
The radiologic findings are considered to be positive if at least three of the above signs are present.

IV. *Auxiliary investigations:*
Degree of hypoxemia, hematocrit, erythrocyte count, estimation of alkali reserve in the blood.

The prevention of cardiopulmonary failure in pulmonary tuberculosis consists of obviating the development of tuberculous cavities, or at least, of their rapid healing. As long as this aim is not attained, it is advisable to keep patients with chronic pulmonary tuberculosis under close supervision. This makes a correct assessment of their working capacity possible and prevents their being completely excluded from employment by overlooking signs of impending cardiopulmonary failure.

It is worth noting that the exact study of pulmonary hemodynamics has confirmed the value of simple examination methods in early diagnosis.

The dictum of Thomayer, according to Pelnar,[11] with regard to cardiac cirrhosis of the liver, also holds true in this condition: "That it would be possible to avoid the development of such gross changes if we always made a thorough examination of our patients as a whole, without reference to what they are complaining of—and if the patients themselves comprehended the gravity of their symptoms in time."

SUMMARY

We have made an investigation of cardiopulmonary failure in tuberculosis over the years 1946-1957. Our experience demonstrates the increased incidence of cardiopulmonary failure in the post war years in the face of a continuous fall in mortality from tuberculosis. The factors increasing this incidence are:

1. The duration of tuberculosis before admission to the clinic has increased almost three-fold in the past ten years—from 2.8 years in 1947 to 7.5 years in 1957.

2. The average age of patients who died at the clinic has increased from 37 to 57.5 years from 1947 to 1957.

3. There has been an increase in retractive fibrotic tuberculosis.

4. In two-thirds of the patients where cor pulmonale was found at necropsy, it was missed by routine clinical examination.

RESUMEN

Hemos llevado a cabo una investigación de la relación de la tuberculosis con la insuficiencia cardiaca durante los años 1946-1957.

Nuestra experiencia demuestra que la incidencia de la insuficiencia cardiaca ha aumentado en los años de la postguerra frente a un descenso de la mortalidad por tuberculosis:

Los factores que hacen aumentar esta incidencia son:

1. La duración de la tuberculosis antes de la admisión a las clínicas ha aumentado casi tres veces en los pasados 10 años de 2.8 años en 1947 a 7.5 años en 1957.
2. La edad media de los enfermos que murieron en la clínica ha aumentado de 37 años a 57.5 años de 1947 a 1957.
3. Ha habido un aumento en la tuberculosis retractil.
4. En dos tercios de los enfermos en quienes se encontró cor pulmonale al examen postmortem, este padecimiento no se había diagnosticado por el examen clínico de rutina.

RESUMÉ

L'auteur a fait une étude sur la fréquence de l'insuffisance cardiaque chez les tuberculeux de 1946 à 1957. Son expérience montre l'accroissement de fréquence de l'insuffisance cardio-pulmonaire dans les années d'après guerre, parallèlement à la chute continuelle de la mortalité due à la tuberculose. Les facteurs qui ont permis l'augmentation de fréquence sont:

1. La durée de la tuberculose avant l'admission à la clinique a augmenté presque de trois fois pendant les dix dernières années, de 2,8 années en 1947 à 7,5 années en 1957.
2. L'âge moyen des malades morts en clinique a augmenté, de 37 à 57,5 ans de 1947 à 1957.
3. Il y a eu une augmentation des tuberculoses fibreuses avec rétraction.
4. Chez les deux tiers des malades, le coeur pulmonaire a été découvert à l'autopsie et n'avait pas été constaté lors de l'examen clinique.

ZUSAMMENFASSUNG

Wir haben eine Untersuchung des Standes der cardiopulmonalen Insuffizienz bei der Tuberkulose für die Jahre 1946 bis 1957 vorgenommen. Unsere Erfahrung bezeugt die größere Häufigkeit der cardiopulmonalen Insuffizienz in den Nachkriegsjahren angesichts eines anhaltenden Rückganges der Tuberkulosemortalität. Die diese Zunahme bewirkenden Faktoren sind:

1. Die Dauer der Tuberkulose vor der Krankenhauseinweisung ist in den vergangenen 10 Jahren fast um das Dreifache angestiegen, nämlich von 2.8 Jahren im Jahre 1947 auf 7.5 Jahre im Jahre 1957.
2. Das Durchschnittsalter der Patienten, die in der Klinik starben, ist von 37 Jahren auf 57.5 Jahre angestiegen in der Zeit zwischen 1947 und 1957.
3. Es fand sich eine Zunahme der schrumpfenden, fibrösen Tuberkulose.
4. Bei zwei Drittel der Kranken, bei denen ein cor pulmonale bei der Sektion gefunden wurde, war es bei der routinemässigen klinischen Untersuchung nicht entdeckt worden.

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Important Announcements

Notice of Annual Meeting

The 28th Annual Meeting of the American College of Chest Physicians will be held at the Morrison Hotel, Chicago, June 21-25, 1962. The American Medical Association will hold its annual meeting in Chicago, June 25-29.

Scientific Program

Preparations for the 1962 scientific program are now under way. Abstracts of papers for consideration must be received by the program committee prior to *January 1, 1962*. Please forward abstracts, in duplicate, 200 words or less, directly to the chairman of the committee, as follows:

JOSEPH W. PEABODY, JR., M.D., Chairman
Committee on Scientific Program, A.C.C.P.
1150 Connecticut Avenue, N.W.
Washington, D. C.

Differential Diagnosis of the Cardiovascular Diseases through Right and Left Heart Catheterization

A Review

ALDO A. LUISADA, M.D., F.C.C.P. and JAN SZATKOWSKI, M.D.
Chicago, Illinois

Right heart catheterization was well studied in the decade 1940-1950, first by Cournand's group, then by those of Dexter, Bing, McMichael, Lenègre, P. Wood, Burchell, and many others. Their work revealed the normal levels of pressure within the right atrium and ventricle and within the pulmonary artery, as well as the pressure patterns of the various chambers. Dexter *et al.* further described the technique for recording the "wedge pressure" of the pulmonary arteries (pulmonary capillary pressure), which reflects to a great extent both the pressure and the pressure pattern of the left atrium. This was extensively studied by Soulié and his co-workers. Studies of the pressure patterns encountered in the chambers of the right heart, in the pulmonary artery, and in the "wedge" position, first described by the above groups, were further published in 1956 by Luisada and Liu.

Catheterization of the left heart was described in 1952 by Facquet (transbronchial method), and in 1954 by Björk (transthoracic method). Both employ *puncture of the left atrium* and passing of a thin catheter into the left ventricle and then the aorta. The latter method was employed with certain technical modifications by Kent and Fischer. Important contributions were published by Moscovitz *et al.*, and many others. Certain details of the pressure patterns of the left atrium and ventricle and the aorta were published in 1958 by Luisada and Liu.

More recently, new methods for left heart catheterization have been employed: the first is based on the *transthoracic, direct puncture of the left ventricle;* the second, on the penetration of the left ventricle by means of *retrograde aortic catheterization.*** Neither of these allows measurement of the left atrial pressure or the mitral gradient. On the other hand, another method, based on *penetration of the left atrium through the interatrial septum* (Ross *et al.*) during right heart catheterization, provides the above data.

Right heart catheterization permits measurement of *cardiac output* through application of the Fick principle.

Several *functional tests* have been described. The most commonly employed is an *exercise test.* A test based on the use of 1-arterenol (Levophed) has been described by Braunwald while isoproterenol (Isuprel) has been used in our laboratory. Both of them are employed in left heart catheterization, respectively for the study of mitral insufficiency and stenosis.

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*From the Department of Medicine, Division of Cardiology, The Chicago Medical School and Mount Sinai Hospital.
This study was prepared during Dr. Luisada's tenure of Teaching Grants HT-5002 and HT-5182 of the National Heart Institute, United States Public Health Service.

**This method was performed by Zimmerman in the late '40's, but only more recently was reconsidered and applied to clinical use.

TABLE 1—AVERAGE CARDIOVASCULAR PRESSURES IN MAN
(from Luisada & Liu's *Intracardiac Phenomena*, Grune & Stratton, New York, 1958)

RA				RV		PA		Pulm. Wedge	LA				LV		
A	X	V	Mean	Syst.	Late Diast.	Syst.	Diast.	Mean	A	X	V	Mean	Syst.	Late Diast.
5.9	1.5	4.5	3.8	22.1	4.1	21	9.1	14	8.5	12.1	4.5	8.2	7.7	110	7.0

At present, no quantitative evaluation of *blood flow* is possible. The most significant hemodynamic data revealed by catheterization are those of *pressure*. These should be correlated with: (a) the changes of the *pressure pattern*, and, (b) the *cardiac output* and *the cardiac index*.

The average figures of pressure in normal subjects are summarized in Table 1, and the respective levels and patterns are presented in Figure 1. It is apparent that the pressures of both atria (as well as pulmonary wedge pressure) are extremely low; that the right ventricular and pulmonary artery pressures are higher; and that the left ventricular and aortic pressure are the highest.

The various cardiovascular lesions, producing valvular narrowing or insufficiency, obstruction in the lungs, ventricular failure, or resistance to ventricular filling, are clearly revealed by combined right and left heart catheterization. The following is a brief description of the most significant changes, partly gathered from the literature, but chiefly observed in our laboratory in 167 cases of right, 75 cases of left, and 30 cases of right and left heart catheterization.

(1) *Lesions of the Aortic Valve*

Aortic stenosis is best studied by simultaneous or successive measurement of left ventricular and aortic pressures. In severe aortic stenosis, *left ventricular systolic pressures* rise to extremely high levels (200-280 mm. Hg) while aortic systolic pressures are normal or slightly reduced (90-100 mm. Hg). The gradient of pressure which develops between left ventricle and aorta provides the best diagnostic criterium that can be observed (Fig. 2A). However, supportive data are supplied by modifications of the pressure pattern in the aorta (slow rise, deep anacrotic notch, indentations of the top, double peak or flat top, etc.). The *diastolic pressure* of the left ventricle may slightly rise (from the normal 1-4 to

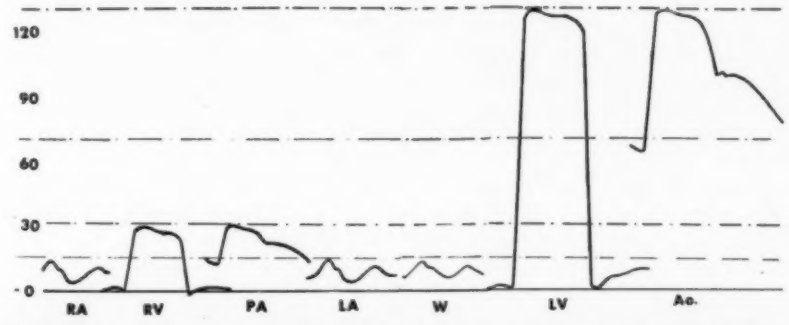

FIGURE 1: The normal pressures and patterns on right and left catheterization.

10-12 mm. Hg*) indicating a *systolic overload* and a slight increase in the residual volume. This should not be confused with left ventricular failure. When this elevation takes place, left atrial and wedge pressures will also rise to the same level because the left atrial blood has to flow in the left ventricle in diastole. Again, this should not be confused with left ventricular failure. It is obvious that the larger the output of the left ventricle, the greater is the systolic gradient if the peripheral resistance is unchanged. This may explain the possible finding of a small gradient in spite of a loud systolic murmur and typical clinical picture. On the other hand, it should be kept in mind that severe aortic obstruction would decrease cardiac output, a fact which is closely linked to the clinical evidence of decreased blood flow in the cerebral and coronary

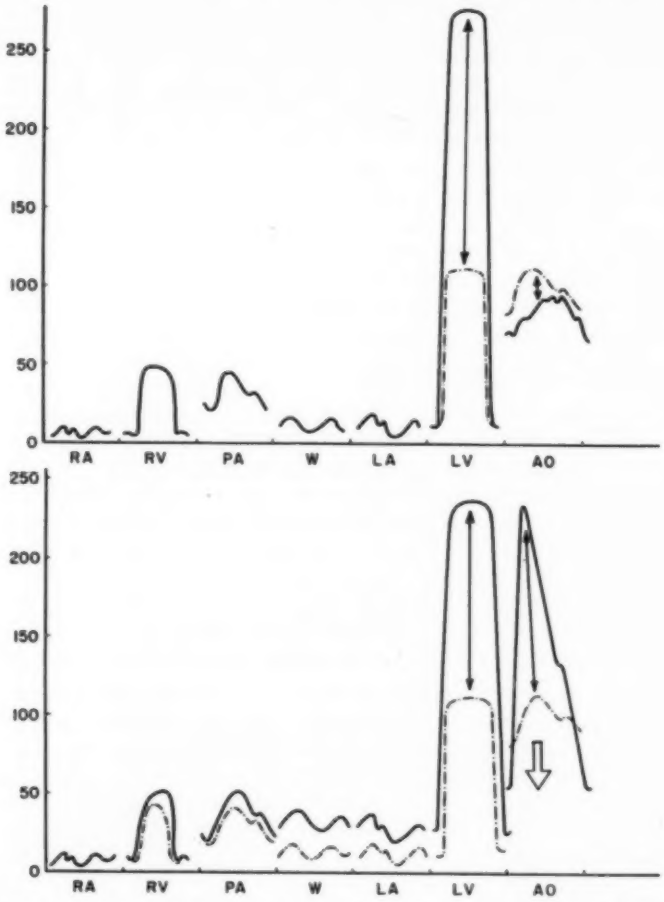

FIGURE 2A (upper): Aortic block caused by *aortic stenosis*. FIGURE 2B (lower): Pressure changes in *aortic insufficiency*.

*This level of 10-12 mm. Hg has been set arbitrarily. Until a better definition and understanding of "mechanical strain" and "failure" is obtained and a separation between the two on a mechanical basis can be established, this level should be accepted as a provisional and empirical dividing line.

vessels. *Left ventricular failure* is often revealed by x-ray evidence of left ventricular dilatation and is accompanied by a marked increase of left ventricular diastolic pressures (15-25 mm. Hg). At the same time, relative mitral insufficiency may develop (see below).

Aortic insufficiency is characterized by a typical change of the aortic pressure, with increased systolic and decreased diastolic pressures (Fig. 2B). The left ventricular tracings show *increased systolic pressure,* which may reach 200 mm. Hg or more. *Left ventricular diastolic pressures, however, tend to rise* due to the regurgitant blood which enters the chamber in diastole, and may reach 10 to 15 mm. Hg. This does not indicate failure as yet. A similar increase of pressure would occur in the left atrium and pulmonary vessels (Fig. 3).

(2) *Conditions Impairing the Flow in the Left Ventricle*

There are several conditions which may decrease the efficiency of the left ventricle. A first group is due to *irreversible lesions preventing completion of left ventricular filling during diastole: fibroelastosis, amyloidosis, or constrictive pericarditis.* In these three conditions, full left ventricular dilatation is prevented from either within the chamber, or within the wall, or externally. This results in an increased left ventricular diastolic pressure, which produces a similar increase of pressure in the left atrium and pulmonary vessels, and a moderate increase of right ventricular and pulmonary artery pressures (Fig. 3A). Several data have been described which should aid the differential diagnosis.

(a) The pattern of the pressure pulse of the left ventricle often presents *a rapid drop* (*dip*) after systole and a rapid rise in early diastole, which is soon checked and followed by *a plateau,* as first described by Hansen and confirmed by many others. This pattern unfortunately is not constant. (b) The pattern of the left atrial pressure pulse may also show an early-diastolic dip.* (c) The left ventricle is *not* dilated on x-ray or physical examination. It is unfortunate that this triad of signs (high LV diastolic pressure, normal LV diastolic size, normal pressure patterns or diastolic dip) can be found in other, more common conditions: (1) *fibrosis* of the left ventricle, often secondary to extensive coronary heart disease or healed myocarditis, a fact which was the object of a recent study by Burwell; (2) *myocarditis* of the left ventricle (rheumatic, viral, bacterial, or toxic). This was found by us in an unusual case simulating mitral stenosis on x-ray inspection (Fig. 4A). It is obvious that all these cases, including those with increased connective tissue within, in, or without the left ventricular wall, as well as those with an inflammatory condition, may have some degree of left ventricular failure, which would add its effects to and could not be separated from the parietal lesion. (3) Another possibility is that of *left ventricular failure* in coronary or hypertensive patients. If there is an overload of the left ventricle (hypertension), a moderate increase of the diastolic pressure (up to 10-12 mm. Hg) may occur without actual failure. On the other hand, a rise of 12 to 25 mm. Hg of the LV diastolic pressure is definite evidence of failure. Usually, in these cases, severe failure is accompanied

*This pattern can occasionally be found in cases of heart failure without fibrosis or constriction. This is proved by Figure 4C.

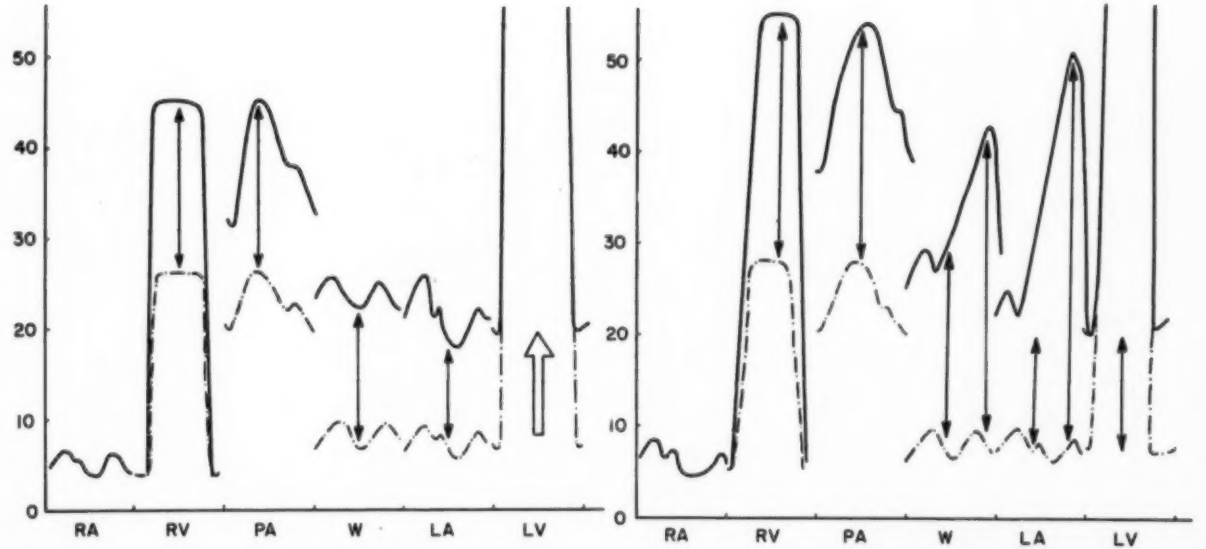

FIGURE 3A

FIGURE 3B

FIGURE 3A: Changes of pressure in *conditions impairing the dilatation of the left ventricle;* fibroelastosis, amyloidosis, constrictive pericarditis of the left ventricle, fibrosis of the left ventricle; *myocarditis* of the left ventricle, or *left ventricular failure* not causing excessive distention of the left ventricle. **FIGURE 3B:** Changes of pressure in *conditions decreasing the contraction of the left ventricle* (myocarditis, left ventricular failure in hypertensive or coronary patients *causing severe dilatation of this chamber with relative mitral insufficiency.)*

by marked dilatation of the left ventricle. Then, stretching of the papillary muscles and dilatation of the mitral ring often lead to *relative mitral insufficiency* (Fig. 3B and 4B). Left atrial pressure tracings present a typical triangular wave of insufficiency. This wave has a peak at the end of systole (slightly prior to or simultaneous with the second aortic sound) and should be called I wave (insufficiency wave) or IV wave, if it is fused with the subsequent V wave. A similar pattern is found in wedge pressure tracings, but the peak often falls in early diastole, due to the transmission delay from LA to pulmonary arteries. The temporary (late systolic), but sometimes severe, increase of LA pressure is sufficient to cause a further rise of mean LA pressure. Then, a certain degree of pulmonary and RV hypertension occurs as a consequence (pulmonary hypertension due to left ventricular failure), as first described by McGinn and White (Fig. 3B). In a case observed by the author, an unsuspected myocardial infarct had caused LV failure and relative mitral insufficiency, and the LA pattern showed an I wave reaching over 60 mm. Hg (Fig. 4B).

In summary, inflammatory, necrotic, or constrictive lesions impairing LV filling, or LV failure unaccompanied by dilatation, cause a primary rise of LV diastolic pressure. This is followed by elevation of pressure in all the chambers and vessels behind the left ventricle up to the tricuspid valve, although they may cause no change in the pressure patterns. On the other hand, inflammatory or necrotic lesions of the LV ventricle or LV failure, accompanied by severe dilatation, cause the same

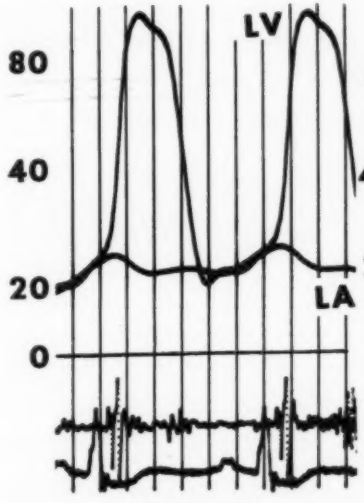

FIGURE 4A

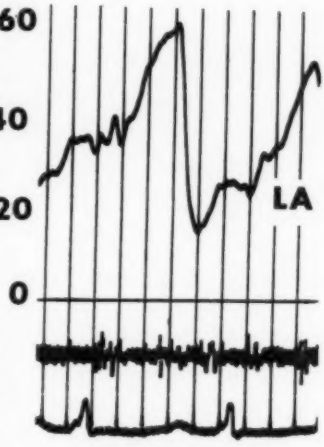

FIGURE 4B

FIGURE 4A: Simultaneous pressure tracings in the left atrium and ventricle demonstrating: (a) normal patterns; (b) no mitral gradient; (c) high diastolic pressure of the LV. Case of *severe myocarditis of the left ventricle without LV dilatation. (Post-mortem)*. FIGURE 4B: Pressure pattern of the left atrium demonstrating: (a) triangular I-V wave, evidence of the regurgitant jet through the mitral valve; (b) high diastolic pressure due to increase of diastolic pressure in the left ventricle. Case of *myocardial infarct in hypertensive patient with severe dilatation of the left ventricle (post-mortem)*.

rise in pressure from the LV to the tricuspid valve plus the pattern of mitral insufficiency in the left atrial and wedge tracings.

(3) *Lesions of the Mitral Valve*

Mitral insufficiency often causes a moderate rise of LV diastolic pressure. This does not exceed 8 to 12 mm. Hg and is probably correlated with a moderate compensatory dilatation of this chamber. Regurgitation through the mitral valve in the absence of LV failure, mitral stenosis, or atrial fibrillation, is accompanied by a typical left atrial pressure pattern. This graphic evidence of the regurgitant jet consists of a triangular wave during ventricular systole reaching its peak before or at the time of the second aortic sound (I wave or IV wave—see Luisada and Liu). This wave may reach a level of 50 to 70 mm. Hg and cause a rise of mean LV pressure and wedge pressures, and secondarily a rise of pulmonary arterial and RV pressures. For this reason, some degree of right ventricular dilatation and hypertrophy often accompanies mitral insufficiency. It may be recognized, if severe, py x-ray inspection and electrocardiography. The wedge pressure tracing also reflects the regurgitant wave (Fig. 5A), but this wave is delayed by the required transmission time and its peak usually falls in early diastole. This is why early observers, studying mitral insufficiency only through wedge pressure measurements, called it a V wave, and were baffled by the problems of a regurgitant jet occurring in systole and causing a wave which appeared in early diastole.

In *mitral stenosis*, left ventricular pressures are normal. In particular, LV diastolic pressure is normal, unless there is LV failure caused by rheumatic carditis, although left atrial pressure is high throughout the cardiac cycle.

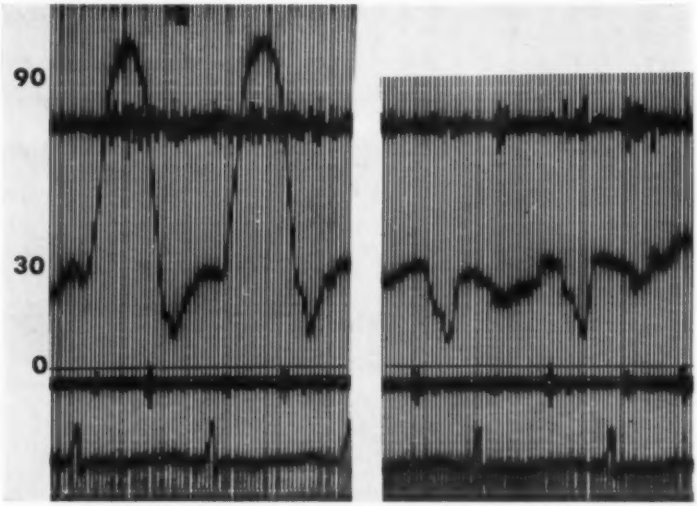

FIGURE 4C: Case of *idiopathic ventricular hypertrophy in congestive failure (necropsy)*. The pattern of the left ventricle (at left) reveals the failure (diastolic pressure=28 mm. Hg). That of the left atrium (at right) also has a diastolic dip and a diastolic plateau.

The gradient which occurs in diastole between the LA and LV pressures is an expression of the *mitral block* (resistance to flow) and is proportional to it (Fig. 5B). If there is no insufficiency of the mitral valve, the *pressure pattern* of the left atrium is normal or presents a tall presystolic *a* wave. With moderate insufficiency, however, the LA pattern shows a slight but typical rise in systole: in the presence of permanent distention of the left atrium with decreased compliance of its wall, even a moderate regurgitation causes a pattern similar to that of the LV

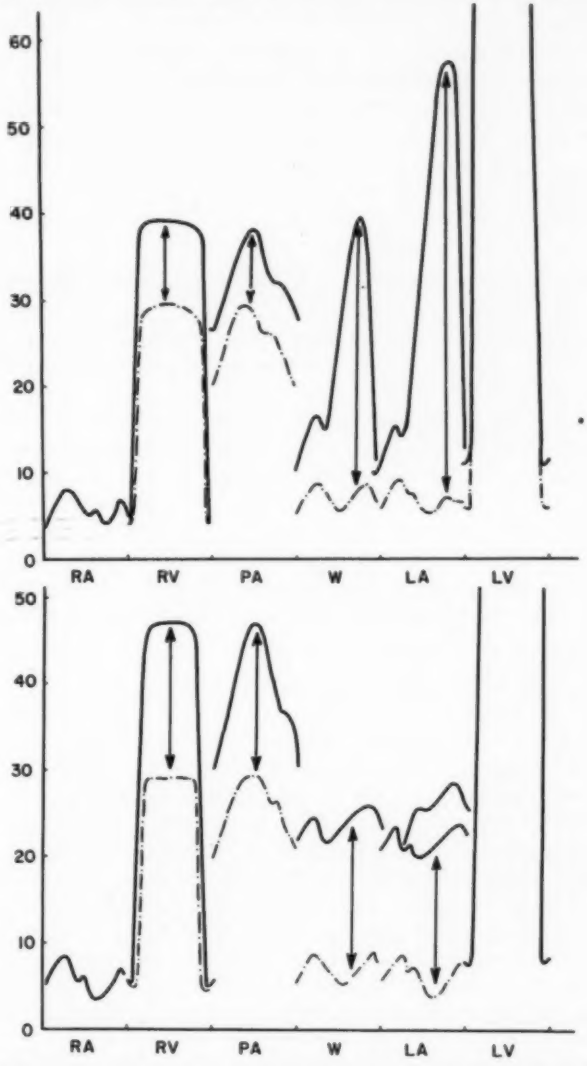

FIGURE 5A (upper): Pressure changes and abnormal pattern in *mitral insufficiency*. Note the high I-V wave caused by the regurgitant jet through the mitral valve. FIGURE 5B (lower): Pressure changes in *mitral stenosis* with sinus rhythm. Pressure gradient between LA and LV. Left atrial pattern often normal.

pressure, though on a smaller scale. It should be noted that mitral insufficiency may be *organic* (caused by retraction of the papillary muscles or deformity of the leaflets) or *functional* (mitral incompetency) (caused by atrial fibrillation or LV failure). It is interesting that, in *atrial fibrillation,* the plateau pattern revealing valvular insufficiency is more marked after a short diastole and is minimal after a long diastole. This is also true with *premature ventricular contractions* interrupting a normal sinus rhythm: often the premature contractions show the plateau pattern of regurgitation while the normal contractions have a normal pattern.

The effects of the mitral block extend backwards to the tricuspid valve causing increased pressures in the LA, pulmonary capillaries, pulmonary artery, and RV. Right ventricular dilatation and hypertrophy are marked and proportional to the severity of the valvular obstruction.

A common occurrence in the advanced stages of mitral valve disease is the association of *mitral stenosis and insufficiency with some degree of pulmonary arteriosclerosis.* In such cases, three outstanding changes are noted by catheterization (Fig. 6A):

(1) a mitral block, revealed by a diastolic gradient between LA and LV;

(2) an abnormal pattern of pressure in the LA consisting in a rectangular plateau during systole (the pressure pattern resembles that of the LV but the rise is smaller);

(3) a pulmonic block, revealed by extremely severe pulmonary and right ventricular hypertension, which is out of proportion with that of the left atrium; in some cases, the systolic pressure of the RV is as high as, or higher than, that of the LV. If, in addition to the above changes, there is *right ventricular failure,* then the diastolic pressure of the RV rises up to 15, 20 or more mm. Hg (Fig. 6B). This causes a rise of pressure in the RA and in the venohepatic system, followed by evident venous and hepatic engorgement, and eventually by peripheral edema.

(4) *Cor Pulmonale*

In pulmonary hypertensive cardiovascular disease secondary to chronic pulmonary lesions, there is a vascular block, either at the capillary level (destructive emphysema, fibrosis, etc.) or at the arteriolar level (pulmonary arteriosclerosis). In both cases, the pressures are normal from the aorta to the pulmonary capillaries (normal wedge pressure revealing normal left atrial pressure); the block is revealed by the pulmonary arterial and right ventricular hypertension. Right ventricular diastolic pressure is normal or slightly elevated (not above 5 mm. Hg) as long as the right ventricle is not in failure (Fig. 7A). As soon as right ventricular failure occurs, this pressure rises, followed by a rise of the right atrial and venous pressures causing venous and hepatic congestion. Relative tricuspid insufficiency, revealed by a plateau pattern in the tracings of the right atrium and large veins, is common (Fig. 7B).

(5) *Pulmonic Stenosis*

In this condition, the pressures are normal in the left heart. There is a pulmonary valve block, which causes right ventricular hypertension.

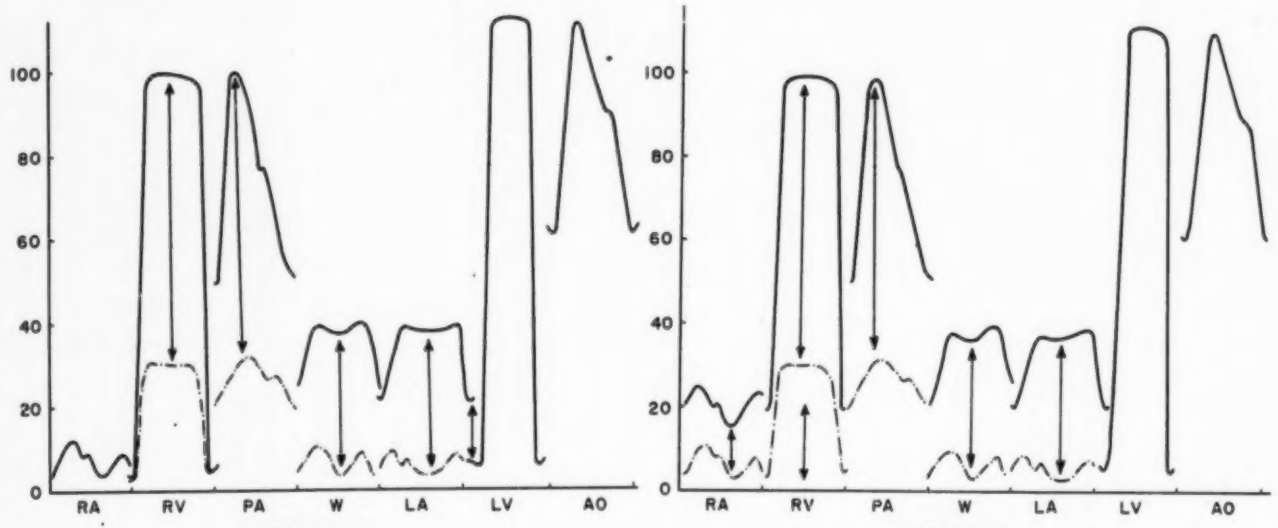

FIGURE 6A

FIGURE 6B

FIGURE 6A: Pressure patterns and levels in *mitral valve disease (mitral stenosis and insufficiency) complicated by pulmonary arteriosclerosis:* double block, at the mitral level and at the level of the pulmonary arterioles. Pulmonary hypertension is out of proportion with the left atrial hypertension. **FIGURE 6B:** Pressure patterns and levels in *mitral valve disease complicated by pulmonary arteriosclerosis and right ventricular failure.* In addition to the changes noted in (A), there is a rise of the RV diastolic pressure. Hence, a rise of pressure in the right atrium and venous system.

The pressure in the pulmonary artery is always lower than in the right ventricle, and may be either normal or low, the latter indicating a more severe obstruction. The pattern of the pulmonary artery pressure is typical, consisting of slow rise, jagged and plateau-like top, and absence of a definite dicrotic wave. Both wedge pressure and LA pressure tend to be low (Fig. 8). If right ventricular failure occurs, then RV diastolic pressure rises, with results which are similar to those seen in decompensated cor pulmonale (Fig. 7B).

(6) *Tricuspid Valve Defects*

In *pure tricuspid insufficiency*, the main abnormality is in the right atrium and ventricle. Right atrial pressures show a marked rise during ventricular systole; this is due to the regurgitation occurring across the tricuspid valve, and causes a triangular wave or a plateau pattern in the atrium, as well as in the peripheral veins and liver, which pulsate like arteries. The compensatory dilatation and hypertrophy of the right ventricle are revealed by (a) a slight increase in right ventricular *diastolic* pressure, and (b) a moderate increase of right ventricular systolic pressure (Fig. 9A).

In *tricuspid stenosis*, all pressures are normal, from the tricuspid valve to the aorta. Only right atrial pressure is elevated by a *tricuspid valve block*. Therefore, while the right atrium is distended, together with the large veins and the liver, the rest of the heart is normal or small. The pattern of the RA pressure often includes a tall presystolic *a* wave, unless atrial fibrillation develops (Fig. 9B). It should be noted that the schemes of Figure 9 indicate only the changes due to a tricuspid lesion. Actually, the tricuspid lesion is nearly always associated with a mitral lesion. Then, both a mitral and a tricuspid block occur. The pressure of the right ventricle, pulmonary artery, and left atrium are *less elevated* than in pure mitral stenosis because the tricuspid valve block tends to decrease these values by decreasing the output of the right ventricle.

(7) *Pericardial Constriction Involving Chiefly the Right Heart*

Localization of the constrictive process over the right heart is not common but may occur. If the constriction predominantly affects *the right ventricle*, the results are similar to those of right ventricular failure. The diastolic pressure of the RV rises causing a rise of the right atrial and venous pressures. A pattern of the right atrial and ventricular pressures may show a "diastolic dip" followed by the "diastolic plateau," described by Hansen, indicating the limitation of ventricular filling. However, not all cases are typical in this respect. Right ventricular and pulmonic systolic pressures may rise slightly as a result of compensatory increase of right ventricular contraction (Fig. 10A). If the constriction predominates *over the lower part of the right atrium*, a gradient of pressures develops between this chamber and the right ventricle, simulating on catheterization the effects of tricuspid stenosis. The clinical picture also is similar to that of tricuspid stenosis. If the constriction causes a *predominant compression of the venae cavae* (rare), then the site of the block is further shifted to the area between the cavae and right atrium.

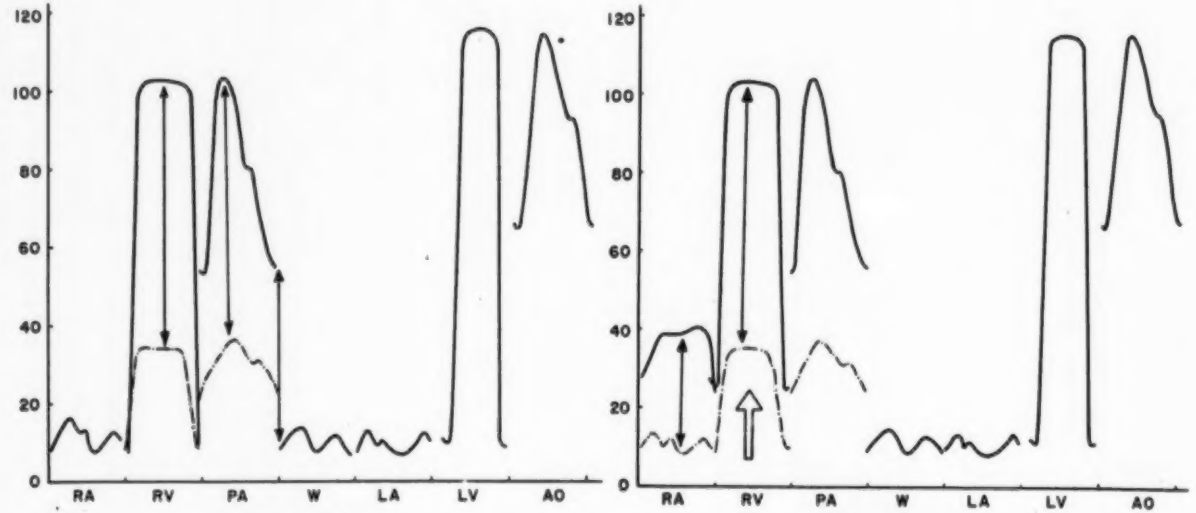

FIGURE 7A

FIGURE 7B

FIGURE 7A: *Chronic cor pulmonale—compensated.* There is a block at the level of the pulmonary arterioles (or capillaries) followed by hypertension in the main pulmonary artery and right ventricle. **FIGURE 7B:** *Chronic cor pulmonale—decompensated.* In addition to the changes of (A), there is right ventricular failure: rise of the diastolic pressure of RV, rise of pressure of RA, relative insufficiency of the tricuspid valve.

Predominant right ventricular failure, caused by myocarditis, ischemic heart disease, or electrolyte imbalance in patients already having "right ventricular strain," produces pressure changes similar to those elicited by constriction of the right ventricle (Fig. 10A) except for the changes in pressure pattern, which are not constant.

(8) *Combined Right and Left Heart Failure*

Right and left heart failure can result from congenital malformations, toxic phenomena, diffuse myocarditis, diffuse ischemic lesions, or metabolic or hormonal diseases. The end-diastolic pressures of both the left and the right ventricle rise. Relative mitral and tricuspid insufficiency, due to dilatation, are common causing sharp systolic peaks in the LA and pulmonary vessels, as well as in the systemic veins. Moderate pulmonary and right ventricular systolic hypertension is frequent (Fig. 10B).

(9) *Interactions of Multiple Lesions*

It has been known for a long time that the existence of *multiple valvular and vascular lesions modifies the typical clinical picture caused by one of them.* Catheterization has proved that the pressure behind one obstruction is less high when *another* obstruction is present before the point of measurement. In particular, the following facts should be kept in mind:

(a) the systolic pressure of the left ventricle, typically raised in aortic stenosis, is less high if there is an associated lesion, like mitral stenosis;

(b) the pressure of the left atrium and pulmonary vessels, typically raised by a mitral valve "block," is less high if there is an associated lesion, like pulmonary arteriosclerosis, tricuspid stenosis, or constrictive pericarditis of the right heart.

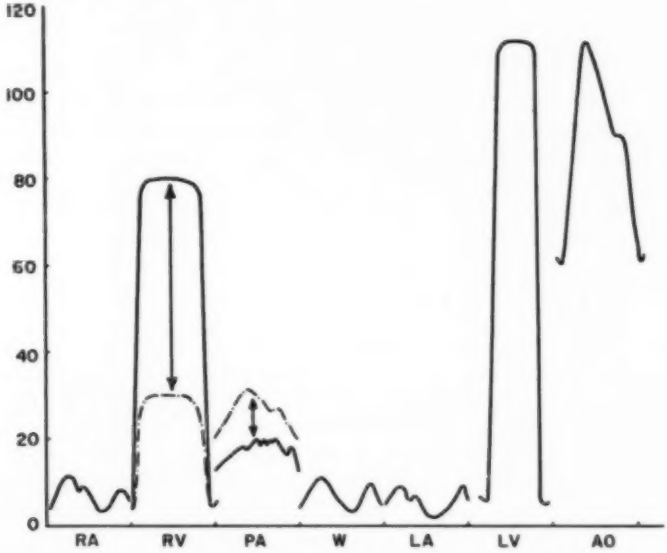

FIGURE 8: The pressure patterns and levels in *pulmonic stenosis:* pulmonic block.

The same result, though less marked, occurs when there is an *escape* of blood from the chamber with high pressure through regurgitation or shunting of blood. This is true in aortic stenosis plus mitral insufficiency and in mitral stenosis plus atrial septal defect (Lutembacher's syndrome).

A similar decrease in pressure before an obstruction occurs whenever the overloaded chamber goes into failure. Left ventricular failure decreases the left ventricular hypertension of aortic stenosis as well as the gradient across the aortic valve; right ventricular failure decreases the right ventricular hypertension of pulmonic stenosis as well as the gradient across the pulmonic valve. Right ventricular failure decreases the right ventricular, pulmonic, and left atrial hypertensions of mitral stenosis, as well as the gradient across the mitral valve. It is unfortunate that a similar fact, though less marked, occurs when cardiac output is decreased by rest, sedation, or use of diuretics. Even digitalis may decrease the gradient across the stenotic mitral valve by causing longer diastoles which decrease the engorgement of the left atrium. For this reason, functional tests have been devised with the purpose of increasing cardiac output and better revealing gradients of pressure.

(10) *Functional Tests in Catheterization*

The oldest described functional test is *exertion*. This is applicable only to right heart catheterization because the special position of the patient and the fear of damaging the heart when a needle is inserted into one of its chambers prevents its use in the left heart catheterization. The exercise is done with a special swing, which the supine patient moves with one foot, or on a special bicycle. Exertion increases venous return, heart rate, and cardiac output. A fixed obstruction (pulmonic, aortic, or mitral block; pulmonary arterioles constriction; arteriosclerotic narrowing of pulmonary vessels) limits the output increase. Unfortunately, primary myocardial disease, myocarditis, amyloidosis of the heart, or heart failure would also be accompanied by inadequate increase of cardiac output.

Narrow pulmonary vessels can be dilated if the narrowing is functional, not if it is due to structural lesions. *Pulmonary vessel dilatation* has been attempted by various means. *Oxygen inhalation* seems to be followed by moderate vasodilatation and decreased pulmonary vascular resistance. Several drugs, like *acetylcholine, reserpine,* and *ganglionic blocking agents* have been tried. However, these drugs induce both systemic and pulmonary vasodilatation. As the musculature of the systemic vessels is more active, systemic effect will dominate causing a decrease of venous return and a drop in pressure in the pulmonary artery. Therefore, only comparisons between systemic and pulmonic pressure and repeated measurements of cardiac output and pulmonary vascular resistance can ascertain whether pulmonary vasodilatation has occurred.

Mitral stenosis and insufficiency, and aortic stenosis are less evident in the presence of reduced cardiac output. In order to increase the gradients, two pharmacological tests can be used. The first, suggested by Morrow, consists of the slow intravenous injection of 4 cc. of 0.2 per cent *arterenol (Levophed)* in 1000 cc. of physiologic solution. This, by increasing peripheral resistance, will increase left ventricular systolic

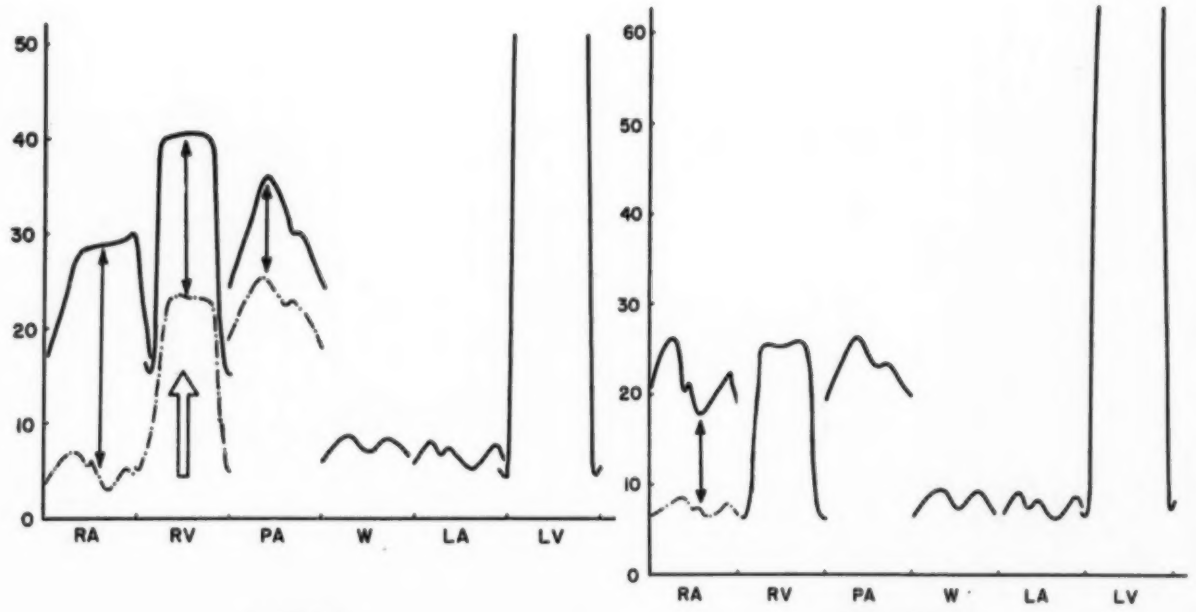

FIGURE 9A

FIGURE 9B

FIGURE 9A: Pressure patterns and levels in *tricuspid insufficiency:* systolic plateau in the right atrium, slight increase of diastolic pressure in RV. FIGURE 9B: Pressure patterns and levels in *tricuspid stenosis:* tricuspid block causing high pressure in RA and in the venous system.

pressures and thus accentuate mitral regurgitation. The second has been used in our laboratory. Following preliminary tests (prior to catheterization) with measurements of blood pressure and heart rate, 0.4 mg. of *isoproterenol (Isuprel)* in 500 cc. of physiologic solution is slowly injected into a vein. The ECG is monitored and the heart rate is counted. When the rate has increased to 120/min., the injection is interrupted. This test, by causing tachycardia, increases the gradient of pressure across the mitral valve and better reveals a mitral stenosis.

(11) *Structural Lesions Versus Functional Disturbances*

One of the main purposes of cardiac catheterization is to ascertain the existence of valvular lesions, to evaluate their nature and severity, and to differentiate them from the results of myocardial damage or dysfunction. The last part of this statement may come as a surprise to some readers because of the firmly established conviction that auscultation alone is usually able to establish or exclude the diagnosis of valvular lesions. Unfortunately, this is not so. In a minority of cases, auscultation and phonocardiography may lead to suspicion of a valvular lesion while the murmurs are caused by a functional mechanism based on myocardial damage. This is occasionally true, not only in cases with apical or basal systolic murmurs, but also in cases with apical or mid-precordial diastolic or presystolic murmurs. Roentgenology and electrocardiography may be of help but occasionally give undecisive data. The clinical picture of the above conditions may be similar to that of mitral stenosis. It is not often realized that pulmonary congestion is a phenomenon which may be caused by either a dynamic mitral block, or a structural block within the left ventricular wall, or a functional impairment of the same wall. This differentiation is the most important problem for which cardiac catheterization is employed.

Right heart catheterization is able to distinguish between the right ventricular hypertensions of pulmonic stenosis, pulmonary disease, and mitral stenosis. In the first, there is a gradient across the pulmonic valve; in the second, a gradient between pulmonary artery and wedge pressure (left atrium); in the third, all pressures, from the LA to the right ventricle, are elevated. On the other hand, right heart catheterization is unable to distinguish between the pulmonary hypertensions caused by myxoma of the left atrium, mitral stenosis, structural lesions of the left ventricle (fibroelastosis, amyloidosis, fibrosis, myocarditis), or various causes of left ventricular failure. This differentiation requires study of (a) the gradient between pulmonary arterioles and left atrium; (b) the gradient across the mitral valve; and (c) the diastolic pressure of the left ventricle. Direct puncture of the left ventricle or retrograde aortic-left ventricular catheterization would permit evaluation of the last point. For point (b), only left atrial catheterization (transbronchial or transthoracic) may give the answer.

Although the pattern of the "wedge" tracing is often helpful in differentiating mitral stenosis from mitral insufficiency, more definite information is obtained through left atrial puncture.

Attempts to quantitate mitral stenosis yield only approximate estimates. This is obtained by calculation of the mitral area by means of Gorlin's formula plus measurement of cardiac output, and the gradient

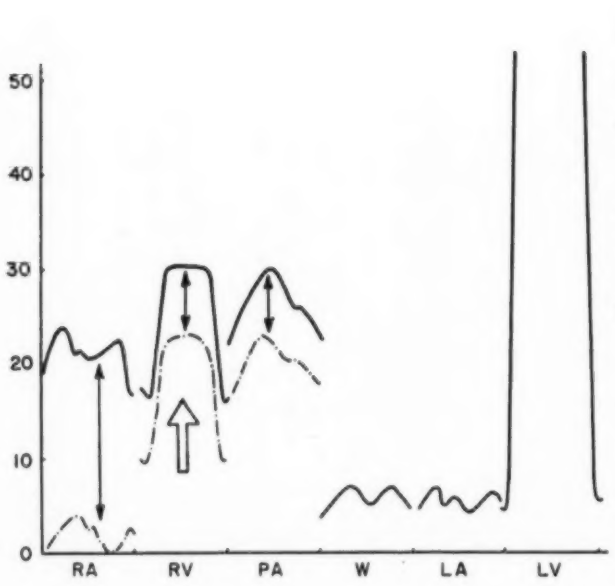

FIGURE 10A

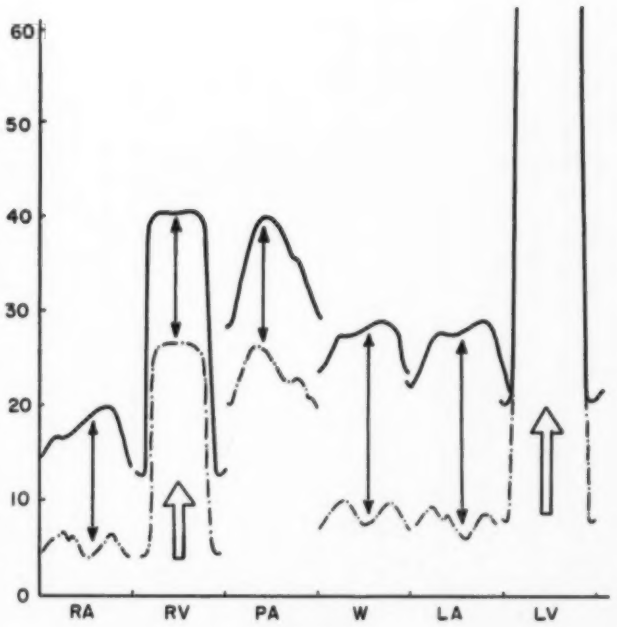

FIGURE 10B

FIGURE 10A: *Constrictive pericarditis predominately affecting the right ventricle* causes an increase of diastolic pressure in the RV with increase of pressure in the RA and venous system. A moderate, compensatory increase of systolic pressure in RV is common. Isolated right ventricular failure would simulate this picture. FIGURE 10B: *Right and left ventricular failure.* Relative mitral and tricuspid insufficiency. Moderate pulmonary hypertension.

across the valve. For quantitation of a mitral insufficiency, direct puncture of the left ventricle and cine-ventriculography is probably the best method.

Still, there are conditions where all the above methods fail to give an accurate answer:

(a) mitral insufficiency plus stenosis;

(b) mitral stenosis plus left ventricular failure or other valvular lesions;

(c) chronic pulmonary disease plus left ventricular failure;

(d) right plus left ventricular failure.

The functional tests which have been previously described may give interesting data but it is the impression of the authors that accurate data cannot be obtained even through their use.

Conclusions

Basing their statements both on personal data and on those of the literature, the authors summarize the dynamic changes of the heart and large vessels revealed by right and left heart catheterization. Simple schemes are used to present the most important changes of pressure.

Right heart catheterization is sufficient to diagnose tricuspid and pulmonic valve lesions. Differentiation of the pulmonary hypertension of pulmonary disease from that of mitral stenosis is also possible. On the other hand, right heart catheterization alone cannot distinguish the engorgement of the pulmonary vessels and the pulmonary hypertension caused by mitral valve "block" from that caused by constriction, restriction, or inflammatory damage of the left ventricular wall, or even from that caused by left ventricular failure due to other causes.

Left heart catheterization has revealed two hemodynamic patterns of left ventricular failure, one with a large left ventricle and frequent evidence of relative mitral insufficiency in the left atrial tracing, and another without left ventricular enlargement and with normal left atrial pressure pulses. Representative tracings for both are presented.

The differential diagnosis between left heart failure with relative mitral insufficiency on the one hand and organic mitral insufficiency on the other is based on the finding of a severely elevated diastolic pressure in the left ventricle plus a typical left atrial pattern, found in the former.

The differential diagnosis between left heart failure with normal-sized left ventricle on the one hand, and mitral stenosis on the other is based on the finding of a severely elevated diastolic pressure in the left ventricle and a normal gradient across the mitral valve, which are found in the former.

The differential diagnosis between left heart failure with normal-sized left ventricle and the congestion of the lungs caused by structural lesions impairing left ventricular diastole (fibroelastosis, amyloidosis, constrictive pericarditis, fibrosis, myocarditis) cannot be made on the basis of catheterization alone because typical changes of the pressure pattern, described in the constrictive forms, may be absent. Clinical criteria, particularly a better response to digitalis in cases with left ventricular failure, may be of help.

SUMMARY

The functional tests used in catheterization are reviewed, and a new test, based on the effect of isoproterenol, is described. However, the utility of these tests is recognized as being limited, and their results as being sometimes equivocal.

RESUMEN

Se hace una revisión de las pruebas funcionales usadas en la cateterización y se describe una nueva prueba basada en el efecto del isoproterenol.

Sin embargo se reconoce que la utilidad de estas pruebas es limitada y que sus resultados son a veces equívocos.

RESUMÉ

L'auteur passe en revue les tests fonctionnels du cathetérisme et il décrit de nouveaux tests, basés sur l'effet de l'isoproterenol. Cependant l'utilité de ces tests est reconnue comme limitée et leurs résultats comme quelquefois routeux.

ZUSAMMENFASSUNG

Es wird über die Funktionsuntersuchungen vermittels Katheterisierung berichtet und ein neuer Test beschrieben, der auf den Effekt von Isoproterenol beruht. Die Nützlichkeit dieses Tests ist jedoch begrenzt, die Ergebnisse manchmal nicht eindeutig.

SUMMARY OF CURRENT THERAPY

Vasopressor Therapy for Cardiac Arrhythmias

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Cardiac arrhythmias and conduction defects, if associated with hypotension, often can be *"aborted"* when the blood pressure is restored to normal levels.[1,2] Even in those arrhythmias which do not terminate with recovery of blood pressure, vasopressor drugs *"support"* the coronary perfusion pressure until slower-acting anti-arrhythmic agents can correct the arrhythmia. In this latter way, proper vasopressor therapy *"buys time"* for the patient.[1,3,7]

Mechanism

The height of the systemic blood pressure is one of the most important determinants of the coronary blood flow. A drop of one-third in coronary flow may occur when the systemic blood pressure is reduced from a mean of 100 to 80 mm. of Hg.[1]

Many cardiac arrhythmias cause a reduction in systemic blood pressure.[1,3] Premature atrial and ventricular systoles and rapid supraventricular and ventricular arrhythmias may reduce both systemic blood pressure and coronary flow.[1,2] In supraventricular arrhythmias, the higher the ventricular rate, above 180 per minute, the greater the reduction in cardiac output, systemic blood pressure and coronary blood flow. With ventricular tachycardia, ventricular rate alone is not the principal determinant because ventricular tachycardia with a normal rate is apt to induce a precipitous drop in systemic blood pressure.

Vasopressor drugs such as norepinephrine probably are the most effective dilators of the peripheral coronary bed. They may cause an increase in blood flow many times more than would be expected for a particular level of pressure. Therefore, vasopressor drugs which increase the coronary blood flow by virtue of the fact that they re-establish systemic blood pressure, in addition, act as dilators of the peripheral coronary bed.

Sympatheticomimetic amines may terminate arrhythmias. Some investigators believed that the increase in systemic blood pressure stimulated aortic pressoreceptor centers and that a cardio-inhibitory reflex transmitted by way of the vagus nerve terminated the arrhythmia.[3] Personal investigations in the "denervated heart" demonstrate that arrhythmias could be terminated by merely restoring the systemic blood pressure either with a snare applied to the aorta or with vasopressor drugs.[1] These studies would suggest that the arrhythmias are terminated by a direct "pressor" action on the myocardium. It was hypothesized that the restoration of pressure acted by (1) increasing coronary perfusion which washed out irritating arrhythmogenic substances, (2) if the arrhythmia was perpetuated by myocardial ischemia, increased nutrition which results from restoration of pressure, terminated the arrhythmia, (3) the increased pressure within the myocardium affected an inhibitory center in the heart itself.

The exact site of action of the vasopressor drugs in terminating cardiac arrhythmias still has to be elucidated although there is no doubt of a direct pressor action on the myocardium itself. These studies do not exclude the possibility that the increase in blood pressure stimulates pressoreceptor organs in the aortic body or carotid sinus which starts a cardio-inhibitory vagal reflex. This reflex, however, is not the sole critical method of action.

Clinical Experience

Sixty per cent of arrhythmias promptly terminated when the pressure was boosted. These include atrial tachycardia, flutter, fibrillation and ventricular tachycardia. In the other patients, the restoration of the systemic blood pressure appeared to improve the coronary perfusion pressure while the cardiac arrhythmias continued.

Mortality Rate of Cardiac Arrhythmias Associated with Coronary Occlusion

It is important to consider cardiac arrhythmias as an emergency in patients with coronary artery occlusion or narrowing, especially if hypotension supervenes, because of the high mortality rate. If a coronary artery is occluded or narrowed, the collateral circulation helps to nourish the ischemic zone of myocardium. If the collateral circulation is adequate, myocardial necrosis may be prevented or limited. This is demonstrated by the fact that the area of an infarction is usually much smaller than the geographic area supplied by the occluded coronary artery. If, however, the collateral circulation in an infarcted area also fails, extensive ischemia and necrosis of the myocardium occur. Therefore, when the systemic blood pressure falls during an arrhythmia, collapse of the collateral coronary circulation results in more extensive myocardial necrosis. This necrosis probably accounts for the significant mortality rate during cardiac arrhythmias. The enormous mortality rate when supraventricular and ventricular tachycardia are associated with myocardial infarction has been reduced by the judicious use of vasopressor drugs.

Sinus Bradycardia

When sinus bradycardia is associated with hypotension following an acute myocardial infarction, the restoration of blood pressure often corrects the extreme vagotonia and the rate increases.[2]

A-V Heart Block

When ischemia of the myocardium affects the A-V node, or bundle of His, first, second or third degree heart block may result. As heart block corrects itself in the convalescent stage of the acute myocardial infarction, there usually is no need to treat the disorder unless Adams-Stokes syndrome occurs. If, however, heart block is associated with hypotension, restoration of the systemic blood pressure with a vasopressor drug often facilitates correction of the heart block because it restores the collateral coronary perfusion pressure.

Premature Systoles

Both supraventricular and ventricular premature systoles, associated with acute hypotension following a myocardial infarction, disappear when the systemic blood pressure is restored. Because frequent premature systoles may herald a more serious ectopic arrhythmia, such as ventricular tachycardia or ventricular fibrillation, the sudden occurrence of hypotension when frequent premature systoles supervene following a myocardial infarction is an indication for treatment with vasopressor drugs.

Paroxysmal Atrial Tachycardia, Atrial Flutter and Fibrillation

These ectopic supraventricular tachycardias often terminate when the systemic blood pressure is restored. There seems to be no difference in results in a patient who has sustained a myocardial infarction or who has an intact coronary circulation.

Ventricular Tachycardia

This serious arrhythmia often terminates as soon as the systemic blood pressure is restored to pre-arrhythmic levels. Vasopressor drugs should be used particularly in the patient who has sustained a myocardial infarction.

Precautions of Vasopressor Treatment

It is a paradox that all anti-arrhythmic agents also may cause more serious arrhythmias than the ones being treated. We have noted that when the blood pressure is raised to hypertensive levels, serious ventricular arrhythmias may result.[1,2] This has been confirmed by other investigators.[5] When the systolic blood pressure is raised above 180 mm./Hg, ventricular tachycardia and fibrillation may result. These arrhythmias usually disappear when the blood pressure drops to normotensive levels. Therefore, when vasopressor drugs are used the blood pressure must be monitored continuously to avoid excessive blood pressure levels.

Control of blood pressure levels is best affected by merely shutting off the vasopressor agent if it is administered intravenously. The blood pressure cannot be controlled as effectively when the agent is administered intramuscularly; therefore, this method should not be used except in extreme emergencies when facilities for intravenous drip are not available. Many vasopressor drugs have a long action and their use is dangerous when the pressor effect cannot be terminated promptly.

Because of its short-acting effect, norepinephrine is probably the safest drug for the treatment of cardiac arrhythmias. Its pressor effect can be terminated within minutes.

Transitional arrhythmias of a few seconds' duration usually result during the conversion of arrhythmias. Because these ectopic ventricular rhythms are of short duration, they usually do not require further treatment.

SUMMARY

Vasopressor drugs have three principal effects: (1) available blood is shunted to maintain the circulation of vital regions such as the myocardium and brain;[2,4-6] (2) cardiac arrhythmias may be aborted by the direct pressor effect on the myocardium; (3) myocardial blood flow is improved because of the increased coronary perfusion pressure and also a vasodilating action.

Vasopressor drugs such as norepinephrine, metaraminol, methoxamine hydrochloride, hypertensin, mephentermine and phenylephrine hydrochloride may terminate cardiac arrhythmias when hypotension exists. If they do not terminate the arrhythmia, they support the coronary circulation until other slower-acting anti-arrhythmic agents take effect.

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SURGICAL TREATMENT OF CONSTRICTIVE PERICARDITIS

Because of polymorphous anatomo-pathologic alterations, particularly in tuberculous pericarditis, one must be aware of opening the frest encapsulated foci during intervention, since they can easily lead to a secondary spreading of the tuberculous process. It is often difficult to make a differential diagnosis. There is still no agreement as to the classifictaion of symptoms. Phlebography of the ostia of the venae cavae by means of catheterization shows that the normal passage in this area is seldom affected even when there are adhesive alterations in the region of these veins. A careful assessment of the indications for treatment, particularly surgical treatment, is decisive for the outcome. From this point of view, the surgical treatment of hyperacute and acute exudative pericarditis, mainly tuberculous, not only gives successful therapeutic results, but also prevents later development of the disease.

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CALENDAR OF EVENTS

National and International Meeting

Interim Session, American College of Chest Physicians
Denver, Colorado, November 25-26, 1961

7th International Congress on Diseases of the Chest
Council on International Affairs
American College of Chest Physicians
New Delhi, India, February 20-24, 1963

Postgraduate Course

Recent Advances in the Diagnosis and Treatment of Heart and Lung Diseases
Los Angeles, December 4-8

ELECTROCARDIOGRAM OF THE MONTH

Edited By Stephen R. Elek, M.D.

Delayed Conduction in Dystrophica Myotonia

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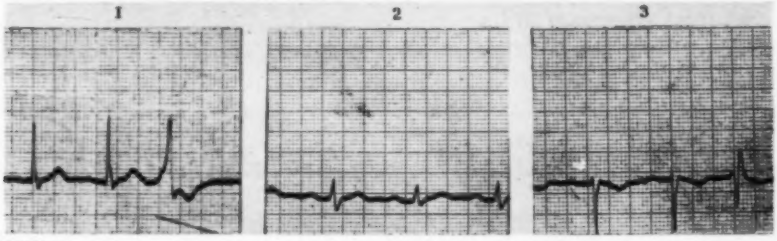
Rochester, New York

A 44 year-old man was admitted to the hospital because of weakness of the extremities, edema of the ankles, and progressive weight gain of 30 pounds in 12 months. He had noted a loss of libido and probably impotence. (He was married and childless.) When grasping objects such as doorknobs, the patient found it difficult to relax his grip. Dyspnea on exertion had appeared. Examination revealed characteristic frontal balding, myotonia, and wasting of the muscles of the hands, and testicular atrophy. Skull x-ray films revealed hyperostosis frontalis interna cranii. Circulation time was prolonged.

Comments

Myotonia dystrophica is a familial disorder with multi-system involvement. It is characterized by myotonia, i.e. prolonged muscular contraction or delayed relaxation following voluntary or mechanical contraction. Frequently present are atrophy of distal muscle components, cataracts, frontal baldness, and endocrine disorders such as seminiferous tubular deficiency. Post-mortem study of the myocardium has shown the presence of atrophy of heart muscle with fibrous replacement. In approximately 90 per cent of reported cases, the electrocardiograms have manifested rhythm or conduction disturbances. Almost half of these patients demonstrate altered junctional tissue conduction. The electrocardiographic limb leads of this patient show characteristic P-R delay with a P-R conduction time of 0.24 seconds. A ventricular premature contraction is seen in Lead I.



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The Committee on Electrocardiography and Vectorcardiography welcomes comments. We should also be pleased to receive EKG's of exceptional interest with brief history. Please submit material to: Stephen R. Elek, M.D., chairman, 6423 Wilshire Boulevard, Los Angeles 48, California.